Draft for Consultation

Advisory on Septage Management in Indian Cities:

Preparation and Implementation of a Septage Management sub-Plan (SMP) as a part of the City Sanitation Plan (CSP)

0. Letter from MoUD

1. Introduction to National Urban Sanitation Policy and City Sanitation Plans

India's National Urban Sanitation Policy (NUSP, 2008) defines sanitation as "safe management of human excreta, including its safe confinement treatment, disposal and associated hygiene-related practices." The NUSP envisages preparation of State Sanitation Strategies by States, and City Sanitation Plans (CSPs) by cities. The overall goal of the NUSP is "to transform Urban India into community-driven, totally sanitized, healthy and liveable cities and towns." The specific goals include awareness generation and behaviour change; open defecation free cities; and integrated city-wide sanitation Box (1).

The NUSP specifically highlights the importance of safe and hygienic facilities with proper disposal (Section 4.2, cf. Box 1); proper disposal and treatment of sludge from on-site installations (septic tanks, pit latrines, etc.) (Section 4.4, c); and proper Operations and Maintenance (O&M) of all sanitary facilities (Section 4.5). The other aspects of the NUSP emphasize awareness generation, attention to the full-cycle of sanitation from safe collection to safe disposal, comprehensive provision and operations and maintenance management of household level arrangements and treatment systems. Therefore, the NUSP has accorded high importance to plan and implement actions for the organized and safe management of fecal matter from on-site installations that hitherto have received limited attention.

This Advisory supplements the NUSP (and annexes on State Strategies and CSPs) by outlining the contents and steps of developing a **Septage Management Sub-Plan (SMP)** as a part of the City Sanitation Plans (CSP) being prepared and implemented by cities. Septage refers here broadly to not only fecal sludge removed from septic tanks but also that removed from pit latrines and similar on-site toilets. This Advisory provides references to CPHEEO guidelines, BIS standards, and other resources that users of this Advisory may refer for details while preparing their SMP.

Box 1: The National Urban Sanitation Polcy (NUSP): Policy Goals

A Awareness Generation and Behaviour Change

4.1 Awareness Generation and Behaviour Change

a. Generating awareness about sanitation and its linkages with public and environmental health amongst communities and institutions;

b. Promoting mechanisms to bring about and sustain behavioural changes aimed at adoption of healthy sanitation practices;

B Open Defecation Free Cities

4.2 Achieving Open Defecation Free Cities:

All urban dwellers will have access to and use safe and hygienic sanitation facilities and arrangements so that no one defecates in the open. In order to achieve this goal, the following activities shall be undertaken:

a. Promoting access to households with safe sanitation facilities (including proper disposal arrangements);

b. Promoting community-planned and managed toilets wherever necessary, for groups of households who have constraints of space, tenure or economic constraints in gaining access to individual facilities;

c. Adequate availability and 100 % upkeep and management of Public Sanitation facilities in all Urban Areas, to rid them of open defecation and environmental hazards;

C Integrated City-Wide Sanitation

4.3 Re-Orienting Institutions and Mainstreaming Sanitation

a. Mainstream thinking, planning and implementing measures related to sanitation in all sectors and departmental domains as a cross-cutting issue, especially in all urban management endeavours;

b. Strengthening national, state, city and local institutions (public, private and community) to accord priority to sanitation provision, including planning, implementation and O&M management;

c. Extending access to proper sanitation facilities for poor communities and other un-served settlements;

4.4 Sanitary and Safe Disposal:

100 % of human excreta and liquid wastes from all sanitation facilities including toilets must be disposed of safely. In order to achieve this goal, the following activities shall be undertaken:

a. Promoting proper functioning of network-based sewerage systems and ensuring connections of households to them wherever possible;

b. Promoting recycle and reuse of treated waste water for non potable applications wherever possible will be encouraged.

c. Promoting proper disposal and treatment of sludge from on-site installations (septic tanks, pit latrines, etc.);

d. Ensuring that all the human wastes are collected safely confined and disposed of after treatment so as not to cause any hazard to public health or the environment.

4.5 Proper Operation & Maintenance of all Sanitary Installations:

a. Promoting proper usage, regular upkeep and maintenance of household, community and public sanitation facilities;

b. Strengthening ULBs to provide or cause to provide, sustainable sanitation services delivery

Source: National Urban Sanitation Policy, Ministry of Urban Development, Govt. of India, 2008

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2. Why Management of On-site Sanitation needs attention

At least a third of Urban Indian Households depend on on-site sanitation

The National Family Health Survey-3 (NFHS, 2005-06) reported that that 17% urban households in India did not have access to any toilets at home, 24% households were sharing toilets (technologies not specified), about 19% had their toilets connected to sewers, the majority had on-site installations – about 27.6% households had septic tanks and 6.1% had pit latrines that were classified as "improved"[1]. Another 5% toilets were as "Flush/pour flush

[1] The UNICEF-WHO Joint Monitoring Program (JMP, 2008, 2010) classifies those toilets that prevent contact with human excreta as "improved". These include facilities that flush or pour-flush to piped sewer system, septic tanks, or pit latrines; or Ventilated improved pit (VIP) latrines, pit latrines with slab or composting toilets. "Unimproved" facilities include defecation in the open, bucket or hanging latrines, open pit latrines or those without a slab, and facilities flushing or pour-flushing to drains or open areas (that is, not to piped sewer system, septic tank or pit latrine). The JMP classifies "shared" toilets as unimproved,

not to sewer/septic tank/pit latrine" – in other words, human excreta from these installations were being let out untreated into land and water bodies without any confinement or treatment. In other words, about 33% households had "improved" on-site systems and a portion of the 5% households that were likely to be on-site unimproved toilets.

The National Sample Survey (CSO, 2008-09) estimated 11% urban Indian households without access to toilets, 8% having pit latrines, and 77% dependant on toilets flushing either into sewers or septic tanks (break down between the two not available). *Therefore, on-site pit latrines and septic tanks account for a substantial proportion of toilets in urban India –more than a third of urban Indian households depend on on-site facilities.*

It may be noted that sewerage systems only partially cover Indian cities – a NIUA (2005) study of 300 Class I and Class II cities noted that …"while all the metropolitan cities have a sewerage system, only a third- of the Class I cities and less than one-fifth of the smaller sized urban centers have a sewerage system. However, the coverage of population by the sewerage system is partial in all these urban centers".

Further, as households without toilets obtain facilities over the next few years, it is likely that many will acquire on-site arrangements like pit latrines and septic tanks in cities and locations where sewerage systems are not available.

Management of septage from on-site facilities appears to be an area of neglect

In contrast with the large proportion of on-site installations, limited attention has been accorded to proper construction, maintenance management and safe disposal of septage from septic tanks and pit latrines. While construction standards have been codified by Indian Standards Organization (ISO), the actual construction was largely left to households to manage – in practice, the installations are subject to local practices and considerable variations are observed. In many instances for example, soak-away outlets are not provided.

Limited capacities and resources with ULBs also resulted in little regulation of maintenance and cleaning of septic tanks and pits – in many cases, households do not report cleaning for a number of years. Some ULBs have de-sludging equipment or there are private players providing cleaning services but the supply of de-sludging services is far from adequate. In many instances, septage is dumped in drains and open areas posing considerable health and environmental risks. Sanitary workers also work in hazardous conditions having to manually clean on-site pits and tanks without adequate protective gear and equipment. In fact, in most Indian cities, there is very limited dis-aggregated information on the types and numbers of on-site toilets and septage disposal systems and practices.

The National Rating of 423 Class I Indian Cities (covering 72% of Indian urban population) on Sanitation (MOUD, Govt. of India, May, 2010) found that 65% per cent (274) of these cities had unsatisfactory arrangements for safe collection of human excreta (whether on-site or sewerage).

Urban India has limited Sewage Treatment Facilities and little experience of Septage Treatment Facilities

There are considerable challenges in respect of treatment of sewage - treatment capacities in Indian cities are only 31% of the generation. The 35 million-plus cities have 68% of the total installed wastewater treatment capacity but nearly 39% of these treatment plants did not conform to discharge standards into water bodies (Central Pollution Control Board, 2009). While conventional sewage treatment facilities are limited (that could potentially also treat septage), there is on the other hand, limited experience in India of developing and managing septage treatment facilities of different types.

Therefore, while considerable proportion of urban Indian households depend on on-site sanitation facilities, their construction, regular cleaning, and safe disposal of septage remain haphazard. Most of the septage is let out untreated posing considerable health and environmental risks. Hence, it is crucial that septage management is accorded urgent attention in Indian cities.

The problems associated with on-site sanitation facilities can be summarized as follows:

(1) Insufficient knowledge/capacity/awareness and public involvement: There is a general lack of awareness of on-site systems and how these should be planned, designed, installed, operated and maintained, especially among system owners and the public at large, and also often among many urban local bodies, who have historically concentrated on centralised sewerage systems;

(2) ***Inappropriate system design and selection processes:*** More often than not, on-systems are not built to national standards, but rather constructed and installed in ad-hoc manner by untrained personnel, and this leads to issues in system performance and failure, higher environmental risks -- in many cases onsite system planning and siting functions are not linked to larger ground water and watershed protection programs and lead to issues such as water quality problems in sub-surface sources, lakes, coastal bays, and estuaries. The practice of constructing septic tanks with outlets connecting to local open drains or channels is widely prevalent in urban India, especially the centres where sewerage systems have not yet come in.

(3) ***Poor O&M:*** Many septic tank system failures have been linked to poor operation and maintenance. Typical causes of failure include infrequent de-sludging which results in sludge-filled tanks, clogged absorption fields, and hydraulic overloading caused by increased occupancy and greater water-use following the installation of new water lines to replace wells and cisterns.

(4) Poor inspection, monitoring, and program evaluation, and regulatory components: Often, institutional mechanisms for inspection, monitoring, and other regulatory measures are non-existent, or even if present, are not effectively enforced.

These problems result in poor system performance, public health threats, degradation of surface and ground waters, decline in property values, and a negative public perceptions of on-site treatment as an effective wastewater management option.

3. Basic Concepts in Septage Management

Human excreta is made up of feces and urine. While urine is less harmful, fecal matter contains pathogens or disease-causing organisms including bacteria, viruses, parasitic protozoa and helminthes, and hence, feces needs to be managed such that these pathogens do not come in contact with human beings and are decomposed or treated i.e. rendered harmless to humans, before being released in the environment.

Box 2: Brief Descriptions of Septic Tank, Pits, Septage, Sludge, etc.

Effluent: the wastewater that flows out of a treatment system (in this case septic tank) or supernatant liquid discharged from the septic tank.

Pit Latrine: latrine with a pit for collection and decomposition of excreta and from which liquid infiltrates into the surrounding soil.

Pour-flush Latrine: Latrine that depends for its operation of small quantities of water, poured from a container by hand, to flush away feces from the point of defecation.

Septic Tank: An underground tank that treats wastewater by a combination of solids settling and anaerobic digestion. The effluents may be discharged into soak pits or small-bore sewers, and the solids have to be pumped out periodically.

Sludge: is the settled solid matter in semi-solid condition – it is usually a mixture of solids and water deposited on the bottom of septic tanks, ponds, etc. The term sewage sludge is generally used to describe residuals from centralized wastewater treatment, while the term septage is used to describe the residuals from septic tanks.

Fecal sludge: Fecal sludge is the solid or settled contents of pit latrines and septic tanks. Fecal sludge differs from sludge produced in municipal wastewater treatment plants. Fecal sludge characteristics can differ widely from household to household, from city to city, and from country to country. The physical, chemical and biological qualities of fecal sludge are influenced by the duration of storage, temperature, intrusion of groundwater or surface water in septic tanks or pits, performance of septic tanks, and tank emptying technology and pattern.

Septage: Fecal sludge produced in septic tanks..

Sullage: Domestic dirty water not containing excreta. Sullage is also called grey water.

Scum: is the extraneous or impure matter like oil, hair, grease and other light material that float at the surface of the liquid, while the digested sludge is stored at the bottom of the septic tank.

Source: Indian Standard: Code of practice for installation of septic tanks (IS:2470 (Part 1) – 1985; Sanitation, Hygiene, and Waste Water Resource Guide, World Bank. http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTWAT/EXTTOPSANHYG/0,,contentMDK:21191474~menuPK:3747921~pagePK:64168445~piPK:64168309~theSitePK:1923181,00.html. Accessed on March 15 2011.

Proper septage management entails regular and i) safe disposal of liquid overflows; and ii) safe removal of septage (semi-solid wastes) from septic tanks and pits. (CSE, 2011).

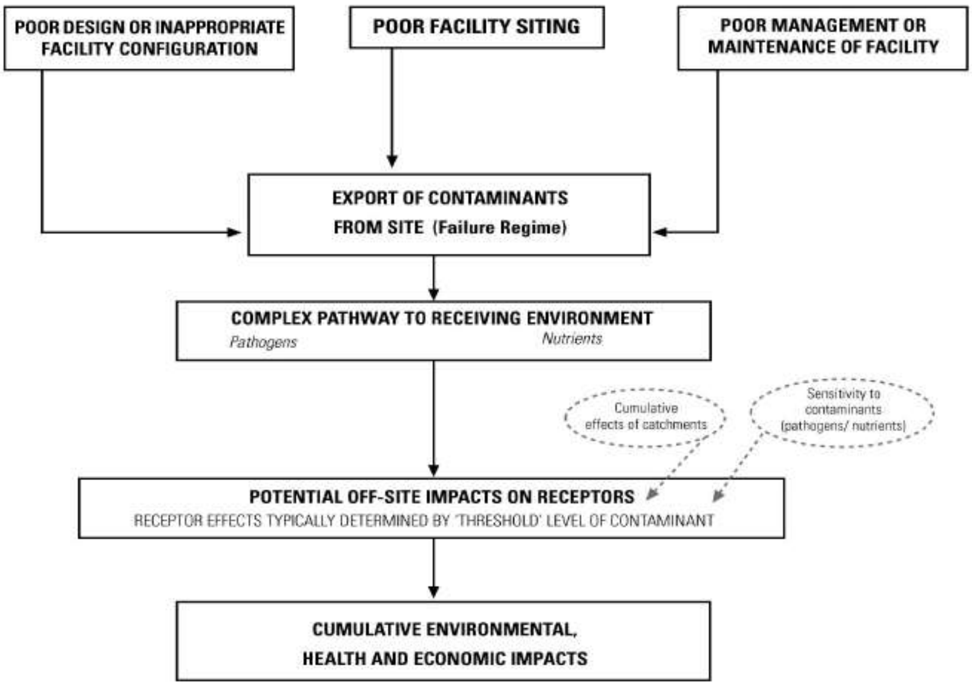
Pit latrines and Septic Tanks are systems that permit safe collection and confinement of fecal matter on-site in a cost-effective manner (compared to more expensive and complex sewerage that carry human excreta away ideally to a treatment facility). When properly constructed and maintained and cleaned, these on-site systems can also convert the pathogen-infested feces into harmless matter to a great extent. However, if these structures are not constructed properly or not cleaned regularly, incoming feces will keep mixing up with decomposed matter thus reducing the efficiency of these structures, and the septage removed or released into the environment will be dangerous to humans.

It is to be noted that some of the pathogens may be present / live in very small amounts but still cause diseases if these came in human contact. Therefore, it is imperative not only that on-site toilets are constructed properly with such design specifications that permit effective decomposition of each classes of these pathogens, but also the removal and disposal of septage should be done safely so that this does not pose a health risk to communities and workers involved.

4. Critical Parameters of On-site systems

The United States Environmental Protection Agency (USEPA)[2] has identified a number of critical problems associated with programs that lack a comprehensive management program, as presented in Fig. 1.

Figure 1: On-site sanitation systems failure and downstream impacts[3]



Better management of on-site facilities and other diffuse sources of pollution are increasingly important as discharge water quality from point sources is improved. On-site sewage facilities that are appropriately sited, designed and managed can provide satisfactory and sustainable sanitation services. However, lack of attention in any of these key areas can lead to failure and the release of hazardous levels of pathogens and other contaminants. A facility is considered to have failed when an unacceptable level of contaminants is released from the

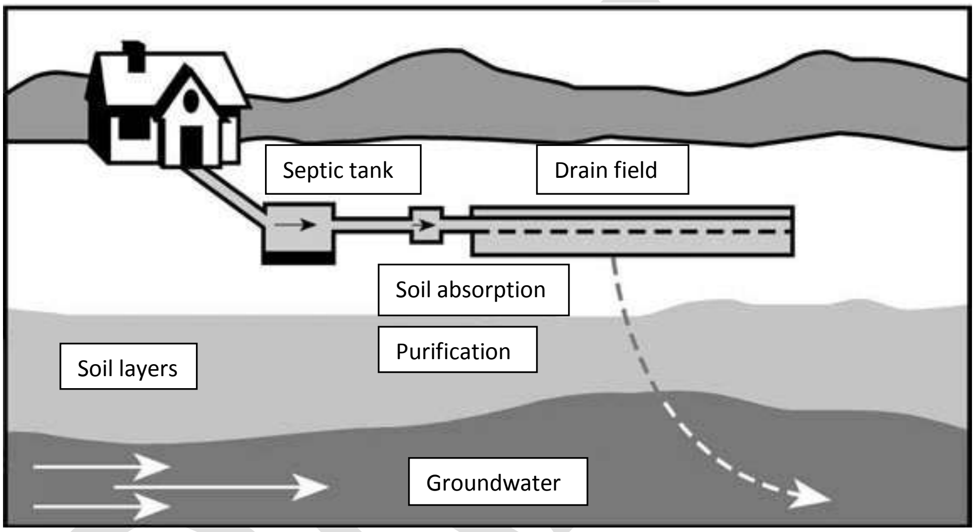
2 Onsite Wastewater Treatment Systems Manual, USEPA, February 2002

3 The Onsite Sewage Risk Assessment System (OSRAS); NSW Department of Local Government (DLG) SepticSafe Program.

facility to either the groundwater or surface water pathways to the environment. Discharge points include house drains, septic tanks, sewage treatment devices and land application areas that leak (e.g. through structural damage, under-sizing, surcharge or runoff caused by hydraulic overloading). Intentional or accidental release of contaminated effluent presents a variable hazard to downstream receptors.

A typical onsite system as shown in the figure below consists of a septic tank and soil absorption system, also known as soak away. Septic tanks are effective in the removal of suspended solids, oil and grease and to a small extent the organic matter in the wastewater. The characteristics of raw and septic tank effluent is presented in Table 1.

Figure 2: Conventional onsite wastewater treatment system



Source: NSFC, 2000.

Table (1): Characteristics of Raw and Septic Tank Effluent			
S. No.	**Characteristics**	**Raw Effluent**	**Septic tank Effluent**
1.	BOD_5, mg/l	210 - 530	140 - 200
2.	SS, mg/l	237 - 600	50 - 90
3.	Nitrogen, mg/l		
	Total	35 - 80	25 - 60
	NH_4^+	7 - 40	20 - 60
	NO_3^-	< 1	<1
4.	Total phosphorus, mg/l	10 - 30	10 - 30
5.	Fecal coliforms, MPN/100 ml	$10^6 - 10^{10}$	$10^3 - 10^6$
6.	Viruses		$10^5 - 10^7$

Septic tank effluent, with appreciable levels of organics, nitrogen and pathogens, has been discharged on soil absorption field for further treatment through biological processes, adsorption, filtration and infiltration into underlying soils. However, either due to shortage of space or inappropriate soil characteristics, soak aways are not provided and the septic tank effluents are discharged without any further treatment. This is a cause of concern on account of the organic carbon (as measured as BOD5), nitrogen, phosphorus and pathogens in the effluent. Discharge of wastewater with organic carbon can lead to the decrease of oxygen and endanger the aquatic organisms in the surface waters. Nitrates in the wastewater can contaminate the ground water and if used for drinking water could cause methemoglobinemia and other health problems for pregnant women. Nitrates and phosphorus in the wastewater can also lead to eutrophication of surface waters. Pathogens reaching the ground or surface waters can lead to human diseases through direct consumption, recreational contact or consumption of contaminated shell fish.

Nitrate, phosphorus, pathogens and other contaminants are present in significant concentrations in most wastewaters treated by onsite systems. Although most can be removed to acceptable levels under optimal system operational and performance conditions, some may remain in the effluent existing conditions. After treatment and percolation of wastewater and passage of water through the first few inches of soil, the wastewater plume begins to migrate downward until nearly saturated conditions exist. The worst case scenario occurs when the plume is mixing with an elevated water table. At that point, the wastewater plume will move in response to the prevailing hydraulic gradient, which might be lateral, vertical or even a short distance upslope if ground water mounding occurs. Moisture potential, soil conductivity, and other soil and geological characteristics determine the direction of the flow. Further treatment occurs as the plume passes through the soil. The degree of this treatment depends on residence time, soil mineralogy and particle size.

The pollutants of concern in the effluent of on-site treatment systems and their potential impacts on ground and surface water resources are summarized in Table 2 (Tchobanoglous and Burton, 1991).

Table (2): Pollutants in the Effluent of On-site treatment Systems

Pollutant	Reason for concern
Total suspended solids	In surface waters, suspended solids can settle and form sludge deposits that smother benthic invertebrates and fish eggs and can contribute to benthic enrichment, toxicity and sediment oxygen demand. Colloidal solids can block sunlight, affect aquatic life and lower the ability of aquatic plants to increase the dissolved oxygen in the water.
Biodegradable organics (BOD)	Biological degradation of organics can deplete the dissolved oxygen in surface waters resulting in anoxic conditions, harmful to aquatic life.
Nitrogen	Nitrogen could lead to eutrophication and dissolved oxygen loss in surface waters. High levels of nitrate nitrogen in drinking water can cause methemoglobinemia in infants and pregnancy complications for women. Livestock can also suffer from drinking water high in nitrogen.
Phosphorus	Phosphorus would also lead to eutrophication and reduction of dissolved oxygen in surface waters.
Toxic organics	Toxic organic compounds present in household chemicals and cleaning agents can be persistent in groundwater and contaminate drinking water sources. They can also affect surface water ecosystems and human health through ingestion of contaminated aquatic organisms (fish and shell fish)

Table (2): Pollutants in the Effluent of On-site treatment Systems	
Pollutant	**Reason for concern**
Heavy metals	Heavy metals like lead and mercury can be toxic to human and aquatic life. They tend to accumulate in fish and shell fish and if consumed by humans could affect their health
Pathogens	Parasites, bacteria and viruses can cause communicable diseases through body contact, ingestion of contaminated water or shellfish. Transport distances of some pathogens (bacteria and viruses can be quite significant)

Onsite systems can fail to meet human health and water quality objectives when fate and transport of potential pollutants are not addressed properly. Failed systems threaten human health if pollutants migrate into groundwater used as drinking water and surface water used for recreation. Failures could be attributed to improper siting, inappropriate choice of technology, faulty design, poor installation practices, poor operation or inadequate maintenance. For example, in high density subdivisions conventional septic tank and soil water infiltration system might be an inappropriate choice of technology as leaching of nitrate nitrogen could result in nitrate concentrations in the local aquifer that exceed drinking water standards. In soils with excessive permeability or shallow water tables, inadequate treatment in the unsaturated soil zone might allow pathogenic bacteria and viruses to contaminate the groundwater. Poorly drained soils can restrict reoxygenation of the subsoil and result in clogging of the infiltrative surface.

Contaminant attenuation (removal or inactivation through treatment processes) begins in the septic tank and continues through the distribution piping of the SWIS, the infiltrative surface biomat, the soils of the vadose zone and the saturated zone. Physical, chemical and biological processes in the anaerobic environment of septic tanks are capable of producing an effluent with a suspended solids concentration of 40 to 350 mg/l, oil and grease levels of 50 to 150 mg/l and total coliform counts of 10^6 to 10^8 per 100 millilitres. Filtration, microstraining and aerobic biological decomposition process in the biomat and infiltration zone remove 90% of the BOD and suspended solids and 99% of the bacteria (University of Wisconsin, 1978). As the treated effluent passes through the biomat and into the vadose and saturated zone, other treatment processes (filtration, adsorption, precipitation and chemical reactions) occur. Table 3 summarizes the case study that characterized the septic tank effluent and soil water quality in the first 4 feet of soil treatment system consisting of fine sands (Anderson et al, 1994).

Table (3): Case study: septic tank effluent and soil water quality				
Parameter	**Statistics**	**Septic tank effluent quality**	**Soil water quality at 0.6 m depth**	**Soil water quality at 1.2 m depth**
BOD (mg/l)	Mean	93.5	<1	<1
	Range	46 – 156	<1	<1
	No. of samples	11	6	6
TOC (mg/l)	Mean	47.4	7.8	8.0
	Range	31 – 68	3.7 – 17.0	3.1 – 25.0
	No. of samples	11	34	33
TKN (mg/l)	Mean	44.2	0.77	0.77
	Range	19 – 53	0.40 – 1.40	0.25 – 2.10
	No. of samples	11	35	33
NO_3-N (mg/l)	Mean	0.04	21.6	13.0

Table (3): Case study: septic tank effluent and soil water quality				
Parameter	**Statistics**	**Septic tank effluent quality**	**Soil water quality at 0.6 m depth**	**Soil water quality at 1.2 m depth**
	Range	0.01-0.16	1.7-39.0	2.0-29.0
	No. of samples	11	35	32
Total Phosphorus (mg/L)	Mean	8.6	0.40	0.18
	Range	7.2 – 17.0	0.01 – 3.8	0.02 – 1.80
	No. of samples	11	35	33
F. coliforms (log#/100 ml)	Mean	4.57	nd	nd
	Range	3.6 – 5.4	<1	1
	No. of samples	11	24	21
F. strep (log#/100 ml)	Mean	3.60	Nd	nd
	Range	1.9 – 5.3	<1	<1
	No. of samples	11	23	20

BOD and suspended solids: Under proper site and operating conditions, on-site systems can achieve significant removal of the suspended solids and biodegeradable organic compounds. The remaining particulate matter BOD is effectively removed at the infiltrative surface and biomat. Colloidal and dissolved BOD that might pass through the biomat is removed through aerobic biological processes in the vadose zone. Poor maintenance could lead to increased BOD and suspended solids concentration in the effluent and clog the infiltration systems.

Nitrogen: in the raw wastewater is primarily in the form of organic matter and ammonia. After the septic tank, it is primarily (>85%) in the form of ammonia. After discharge of effluent to the infiltrative surface, aerobic bacteria in the biomat and upper vadose zone convert the ammonia in the effluent almost entirely to nitrite and then to nitrate. Conventional soil based systems can remove some nitrogen from the septic tank effluent. When nitrate reaches the groundwater, it moves freely with little retardation. Denitrification has been found to be significant in the saturated zone only in rare instances when carbon or sulphur deposits are present. Nitrogen can undergo several transformations in and below a SWIS, including adsorption, volatilization, mineralization, nitrification and denitrification. Nitrification, the conversion of ammonium nitrogen to nitrite and then nitrate by bacteria under aerobic condition is the predominant transformation that occurs immediately below the infiltration zone. The negatively charged nitrate ion is very soluble and moves readily with the percolation soil water. Biological denitrification which converts nitrate to gaseous nitrogen, can remove nitrate from percolating water. Denitrification occurs under anaerobic conditions where available electron donors such as carbon or sulphur are present. It has generally been thought that anaerobic conditions with organic matter seldom occur below soil infiltration fields. Therefore, it has been assumed that all nitrogen applied to infiltration fields ultimately leaches to groundwater. However, Jenssen and Siegrist have reported that about 20% of the nitrogen is removed from wastewaters percolating through the soils. Factors that favour denitrification are fine-grained soils and layered soils, particularly if the fine grained soil contains organic nitrogen.

Phosphorus: The amount of phosphorus leached to the groundwater depends on the soil characteristics, the thickness of the unsaturated zone through which wastewater percolates, the applied loading rate and the age of the system. The fate and transport of phosphorus in soils are controlled by sorption and precipitation reactions. At low concentrations (< 5 mg/l), the phosphate ion is chemic-sorbed onto the surfaces of iron and aluminium minerals in strongly acidic or neutral systems and on calcium minerals in neutral to alkaline systems. As the phosphorus concentration increase, phosphate precipitates. The capacity of the soil to retain phosphorus is rather finite and with continued loading, phosphorus movement deeper into the soil profile can be expected. The ultimate retention capacity of the soil depends on the mineralogy, particle size distribution, oxidation-reduction potential and pH.

Fine textured soils theoretically provide more sorption sites for phosphorus and iron, aluminium and calcium minerals in the soil allow phosphorus precipitation, a process that results in additional phosphorus retention.

Pathogenic microorganisms: Survival times of enteric bacteria in the soil are generally reduced by higher temperatures, lower nutrient and organic matter content, acidic conditions (pH value of 3 to 5), lower moisture content and presence of indigenous soil microflora. Potentially pathogenic bacteria are eliminated faster at high temperatures, pH value of about 7, low oxygen content and high dissolved organic substance content. The rate of bacterial die-off approximately doubles with each 10 degree increase of temperature between 5 and 30^{o}C. The main methods for removal of bacteria in the unsaturated soil are filtration, sedimentation and adsorption with filtration accounting for most of the retention. The size of the bacteria range from 0.2 to 5 microns and physical removal through filtration occurs when the soil micropores and surface water film interstices are smaller than this. Filtration of bacteria is enhanced by slow permeability rates, which can be caused by fine soil textures, unsaturated conditions, uniform wastewater distribution to soil and periodic system resting. Adsorption of bacteria onto clay and organic colloids occur within a soil solution that has high ionic strength and neutral to slightly acidic pH values. Normal operation of septic tank/subsurface infiltration systems result in retention and die-off of most, if not all, pathogens within 2 to 3 feet of the infiltrative surface. With a mature biomat at the infiltrative surface of coarser soils, most bacteria are removed within the first 1 foot vertically or horizontally from the trench-soil interface.

Viruses can be both retained and inactivated in soils. If not inactivated, viruses can accumulate in soil and subsequently be released due to prolonged peak flows from the on-site systems or heavy rains. Soil factors that decrease survival include warm temperatures, low moisture content and high organic content. Soil factors that increase retention include small particle size, high moisture content, low organic content and low pH.

Metals: Metals may be present in wastewater because many commonly used household products contain metals. The fate of metals in soil is dependent on complex physical, chemical and biochemical reactions and interactions. The primary process controlling fixation/mobility potential of metals in subsurface infiltration system is adsorption on soil particles and interaction with organic molecules. Because the amount of naturally occurring organic matter in the soil below the infiltrative surface is low, the cation exchange capacity of the soil and soil solution pH control the mobility of metals below the infiltrative surface. Acidic conditions can reduce the sorption of metals in soil, leading to increased risk of ground water contamination.

Surfactants: commonly used in laundry detergents and other soaps to decrease the surface tension of water and increase wetting and emulsification. Surfactants are the largest class of anthropogenic organic compounds present in raw domestic wastewater. Surfactants that survive the treatment processes and subsequent treatment train can enter the soil and mobilize otherwise insoluble organic pollutants. Surfactants have been shown to decrease adsorption and even actively desorb. Surfactants can also change soil structure and alter wastewater infiltration rates. Surfactant molecules contain both strongly hydrophobic and strong hydrophilic properties and thus tend to concentrate at interfaces of the aqueous system including air, oily material and particles. The behaviour of surfactants in unsaturated soil is dependent on surfactant type. It is expected that minimal retention of anionic and non-ionic surfactants occurs in unsaturated soils having low organic matter content. However, the degree of mobility is subject to soil solution chemistry, organic matter content of the soil and rate of degradation by soil microorganisms. Soils with high organic matter content should favour retention of surfactants because of the lipophilic component of the surfactants. Surfactants are readily biodegradable under aerobic conditions and are more stable under anaerobic conditions. Cationic surfactants strongly sorb to cation exchange sites of the soil particles and organic matter. Thus, fine-textured soils and soils having high organic matter content will generally favour retention of these surfactants.

Septage removal, treatment and disposal

As described earlier, solids settle at the bottom of septic tank forming sludge. Under anaerobic conditions prevailing in the septic tank, anaerobic bacteria degrade the organic matter in the wastewater and settled solids. In a regularly desludged septic tank, sludge occupies a third of the septic tank volume. However, if de-sludging is not carried out regularly the solids level keep increasing and ultimately fills the tank, leaving no room for any treatment of the wastewater. In such a situation, the wastewater flows through the septic tank with little or no treatment and the solids in the wastewater could clog the soil absorption systems. The untreated wastewater would also result in the contamination of ground and surface water sources and the pollution problems elaborated earlier.

Finally, sludge removed from the septic tank would have to be properly treated and disposed on account of the high concentration of organics, nitrogen. Table 4 presents the characteristics of the sludge. Disposal of untreated sludge on land could lead to contamination of ground water through percolation through the soil and if disposed in surface water can cause reduction of dissolved oxygen and eutrophication.

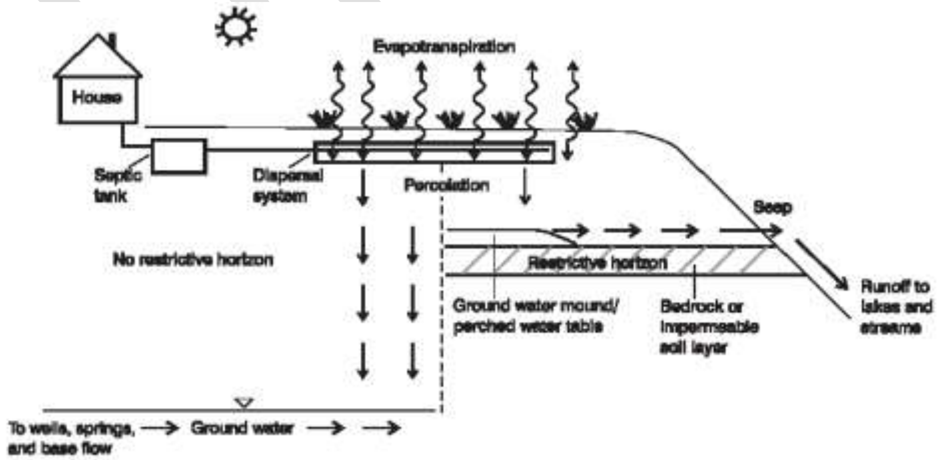
Table (4): Characteristics of Sludge

S. No.	Characteristics	Value
1.	Total solids (%)	< 3
2.	Suspended solids (mg/l)	7,000
3.	COD	<15,000
4.	NH4-N	<1,000
5.	Helminth eggs no/l	4,000

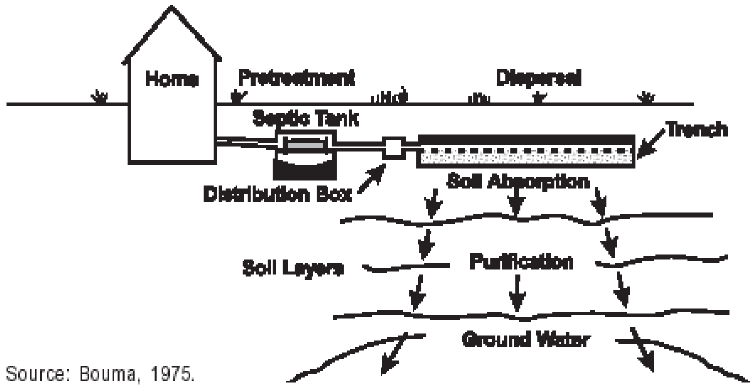
5. Evaluation of potential risk of groundwater pollution

To evaluate the potential risk of ground water pollution from on-site sanitation, it is important to understand the hydrogeological factors which control the direction and rate of groundwater movement and consequently, the movement of pollutants with the groundwater and also the factors that affect survival (elimination or attenuation) of excreted pathogens and undesirable inorganic constituents (such as nitrates) (Fig.3).

Figure 3: Hydrogeological factors of groundwater

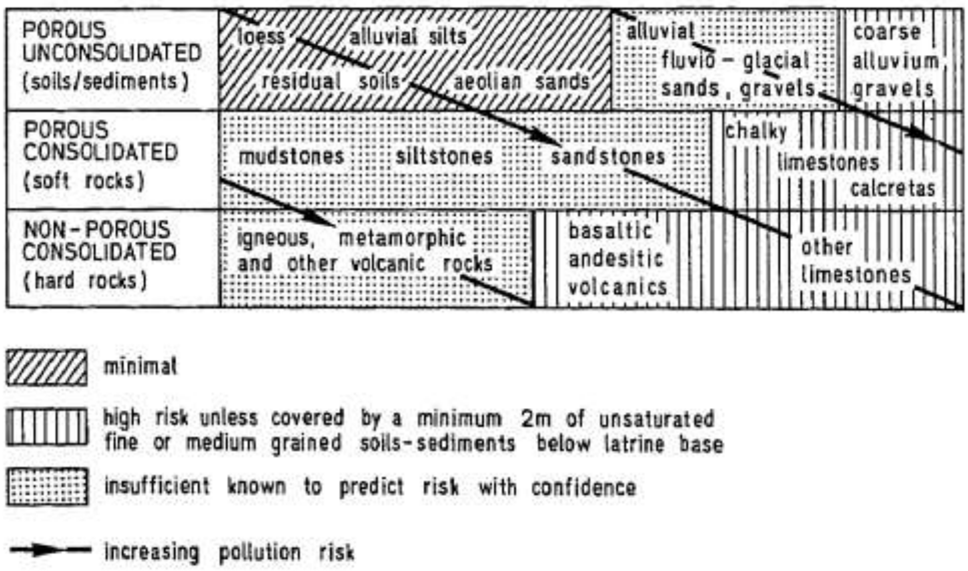


Source: Adapted from Venhuizen, 1995.



Lewis, Foster and Drasar have drawn up a grouping of naturally occurring soils and rocks and a simplified network to assess their pollution vulnerability, as presented in Fig. 4.

Figure 4: Pollution risk relative to various geological environments



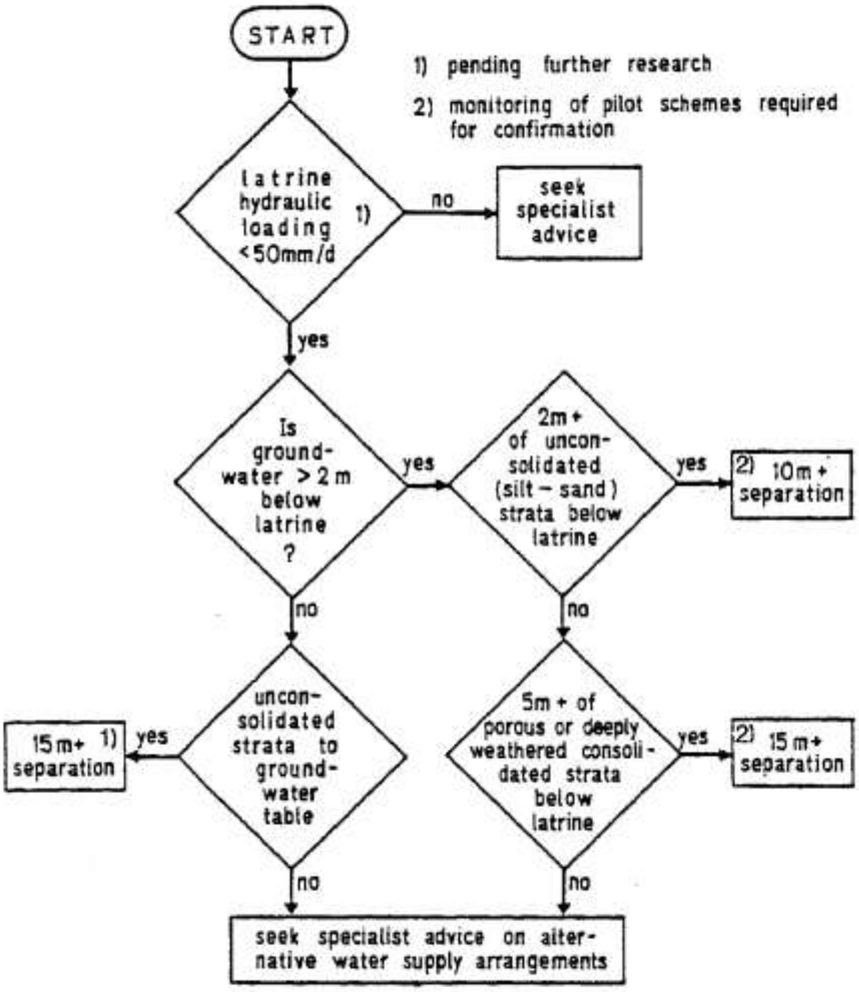
The main findings are summarized below:

1. The pollution problem will normally be limited to unconfined aquifers. Where aquifers are confined or semi-confined, on-site sanitation schemes do not present a pollution hazard provided excavation for the disposal arrangement is not through the confining layer.
2. Bacteria and viruses are the microbial contaminants of concern as they travel the farthest in the soil and ground water. An increase in the nitrate concentration is normally found in unconfined aquifers underlying on-site sanitation.

3. Soil is an effective natural treatment system for the removal of microorganisms and break down or attenuation of many chemicals.
4. The unsaturated zone (above the water table) provides a line of defence against ground water pollution. The nature and the thickness of this zone are the key factors in determining pollution risk.
5. The reduction of microbial pollutants is governed by the movement of ground water which in turn is dependent on the hydraulic characteristics of the soil.
6. Adsorption to mineral surfaces and degradation by other bacteria are the two processes for the reduction of bacteria and viruses in the unsaturated zone. However, desorption of microorganisms could occur with increase in saturation and flow rates.
7. The movement of bacteria and viruses in ground water is dependent on the groundwater flow velocities which are in the range of 1 – 5 m/day, but could also be in the range of 10 to 100 m/day in highly permeable soils.
8. Several field studies have indicated that the lateral migration of pollutants in the saturated zone is limited to a distance that ground water flows in a period of 10 days.
9. The survival of bacteria and viruses is dependent on the temperature, moisture condition and water chemistry.
10. Dilution with uncontaminated ground water is the mechanism for lowering the nitrate concentration in the saturated zone.
11. A “rule of thumb” separation of 15 m is widely adopted between groundwater supply installations and on-site sanitation units. However, the complex process operating in the unsaturated and saturated zones and the heterogeneous nature of the soil makes it difficult to predict any safe distance. In one instance, fecal contaminants have been detected 920 m from the source.

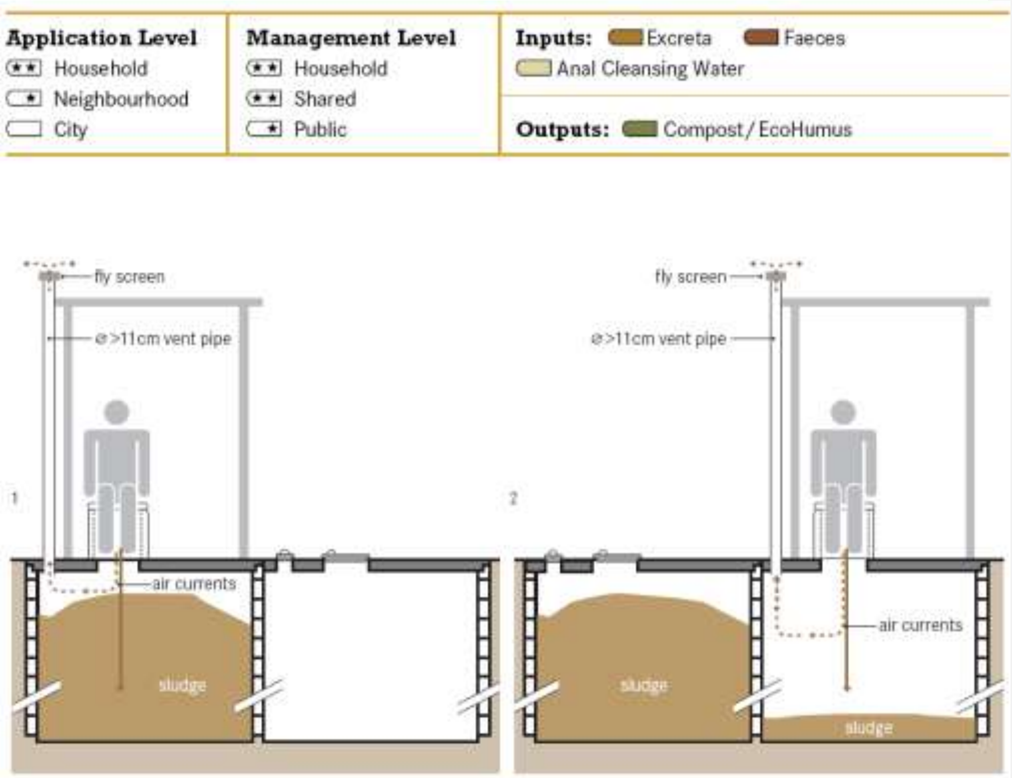
An algorithm for siting of on-site sanitation is presented in Fig. 5.

Figure 5: Algorithm for siting on-site sanitation



6. Design and management of on-site installations

Double Ventilated Improved Pit



The Double VIP has almost the same design as the Single VIP (S3) with the added advantage of a second pit that allows the technology to be used continuously and allows for safer and easier emptying.

By using two pits, one pit can be used while the contents of the second pit rests, drains, reduces in volume, and degrades. When the second pit is almost full (the excreta is 50cmfromthe top of the pit), it is covered, and the contents of the first pit are removed. Due to the extended resting time (at least 1 year of filling/resting) the material within the pit should be sanitized and humus-like. The Double VIP is similar to the Fossa Alterna (S5) technology with the exception that the Fossa Alterna is specifically designed to produce humus and as such, it requires regular additions of soil, ash and/or leaves. The superstructure may either extend over both holes or it may be designed to move from one pit to the other. In either case, the pit that is not being filled should be fully covered and sealed to prevent water, garbage and animals (and/or people) from falling into the pit.

The ventilation of the two pits can be accomplished using one ventilation pipe moved back and forth between the pits or each pit can be equipped with its own dedicated pipe. The two pits in the Double VIP are continually used and should be well lined and supported to ensure longevity.

Adequacy The Double VIP is more appropriate than the Single VIP for denser, peri-urban areas. The material is manually emptied (it is dug out, not pumped out), so vacuum truck access to the pits is not necessary. The users can remove the pit material after a sufficient resting time of one or more years even though the treatment processes in the pit are not complete and the material is not entirely hygienic. The Double VIP technology will only work properly if the two pits are used sequentially and not concurrently.

Therefore, an adequate cover for the out of service pit is required. Double VIPs are especially appropriate when water is scarce and where there is a low groundwater table. They should be located in an area with a good breeze. They are not suited for rocky or compacted soils (that are difficult to dig) or for areas that flood frequently.

Health Aspects/Acceptance The Double VIP can be a very clean, comfortable and well accepted sanitation option, in some cases even more so than a waterfly based technology. However some health concerns exist:

- Latrine leachate can contaminate groundwater;
- Pits are susceptible to failure/overflowing during floods; and
- Health risks from flies are not completely removed by ventilation.

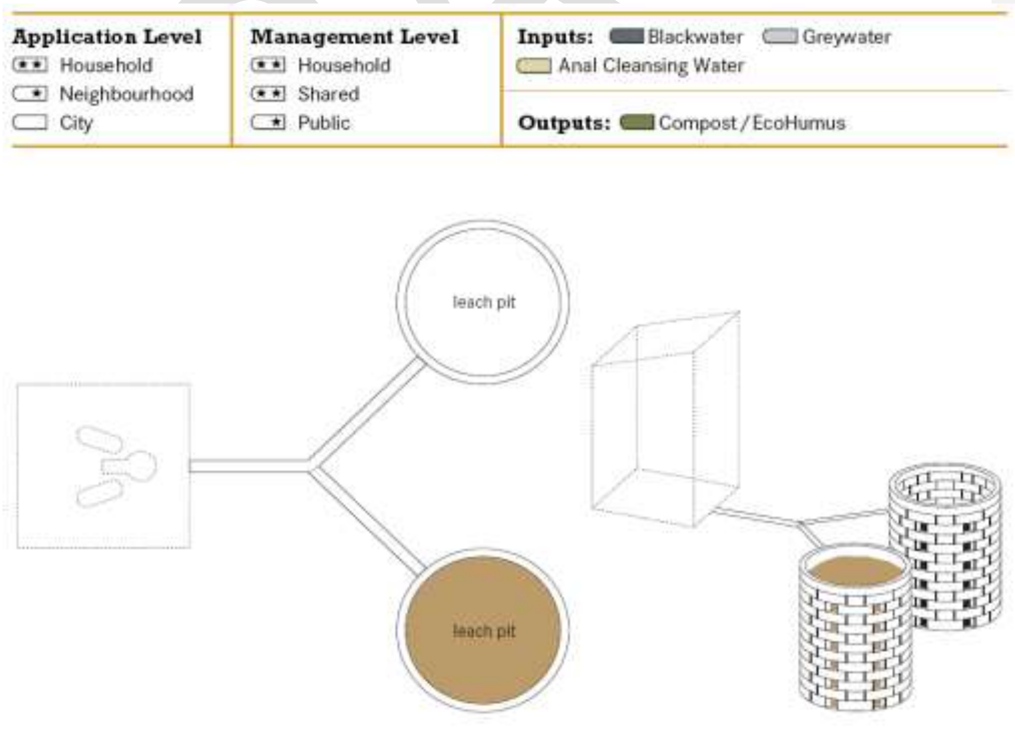
Maintenance To keep the Double VIP free of flies and odours, regular cleaning and maintenance is required. Dead flies, spider webs, dust and other debris should be removed from the ventilation screen to ensure a good flow of air. The out of service pit should be well sealed to reduce water infiltration and a proper alternating schedule must be maintained.

Twin Pits Pour Flush

This technology consists of two alternating pits connected to a Pour Flush Toilet. The blackwater (and greywater) is collected in the pits and allowed to slowly infiltrate into the surrounding soil. With time, the solids are sufficiently dewatered and can be manually removed with a shovel.

The superstructure, toilet and pits, for the Twin Pits with Pour Flush technology can be designed in various ways:

The toilet can be located directly over the pits or at a distance from the pits. The superstructure can be permanently constructed over both pits or it can move from side to side depending on which pit is in use. No matter how the system is designed, only one pit is used at a time. In this way, a continuous cycle of alternating pits means that they can be used indefinitely. While one pit is filling with excreta, cleansing water and flushing water, the other full pit is resting. The pits should be an adequate size to accommodate a volume of waste generated over one or two years. This allows the contents of the full pit enough time to transform into a safe, inoffensive, soil-like material that can be excavated manually. The difference between this technology and the Double VIP or Fossa Alterna is that it allows for the addition of water and does not include the addition of soil or organic material. As this is a water-based (wet) technology, the full pits require a longer retention time to degrade the material before is can be excavated safely. A retention time of 2 years is recommended. The degraded material is too solid to be removed with a vacuum truck.



As the effluent leaches from the pit and migrates through an unsaturated soil matrix, faecal organisms are removed. The degree of faecal organism removal varies with soil type, distance travelled, moisture and other environmental factors. There is a risk of groundwater pollution whenever there is a high or variable water table, fissures and/or cracks in the bedrock. Viruses and bacteria can travel hundreds of metres in saturated conditions. As soil and groundwater properties are often unknown, it is difficult to estimate the necessary distance between a pit and a water source. A minimum distance of 30m should be maintained between the pit and a water source to limit exposure to chemical and biological contamination. It is recommended that the Twin Pits be constructed 1m apart from each other to minimize cross-contamination between the maturing pit and the one in use. It is also recommended that the pits be constructed over 1m from any structural foundation as leachate can negatively impact structural supports.

Water within the pit can impact the structural stability of the pit. Therefore, all walls should be lined up to the full depth of the pit to prevent collapse and the top 30cm should be fully mortared to prevent direct infiltration and ensure that the superstructure is supported.

Adequacy The Twin Pits with Pour Flush is a permanent technology that is appropriate for areas where it is not appropriate to continuously move a pit latrine. It is a water-based technology and is only appropriate where there is a constant supply of water for flushing (e.g. recycled greywater or rainwater). Greywater can be co-managed along with the blackwater in the twin pits. This technology is not appropriate for areas with a high groundwater table or areas that are frequently flooded. In order for the pits to drain properly, the soil must have a good absorptive capacity; clay, tightly packed or rocky soils are not appropriate.

As long as water is available, the Twin Pits with Pour Flush technology is appropriate for almost every type of housing density. However, too many wet pits in a small area is not recommended as there may not be sufficient capacity to absorb the liquid into the soil matrix from all of the pits and the ground may become water-logged (oversaturated).

The material is manually emptied from the Twin Pits (it is dug out, not pumped out), so vacuum truck access to the pits is not necessary.

The Twin Pits with Pour Flush technology will only work properly if the two pits are used sequentially and not concurrently. Therefore, an adequate cover for the out of service pit is required.

Health Aspects/Acceptance The waterseal provides a high level of comfort and cleanliness, with few odours. It is a commonly accepted sanitation option, however some health concerns exist:

- Latrine leachate can contaminate groundwater;
- Stagnant water in pits may promote insect breeding;
- Pits are susceptible to failure/overflowing during floods.

Maintenance The pits must be emptied regularly and care must be taken to ensure that they do not flood during rainy seasons. After a recommended two year resting time, the pits should be emptied manually using long handled shovels and proper personal protection. If the pits are self-emptied there are no operational costs except for any replacements to the structure or slab in the event of damage.

Septic Tank

Septic tanks, normally designed with holding periods of 1 to 2 days, functions as a settling and digestion unit. The solids in the wastewater settle to the bottom of the tank where they undergo anaerobic degradation along with the organic matter in the wastewater. Studies have shown that only about 30% of the settled solids are anaerobically digested in the septic tank. Hence, there will be a build up of solids in the settling tank, which if not removed frequently will affect the performance of the settling tank. Oil and grease and other lighter material will rise and float on the surface the liquid. This is referred to as scum. The tank is designed that the sludge and scum together occupy about ½ to 2/3rd of the tank's capacity (prior to de-sludging). Studies have established that a liquid retention of time of 24 hours ensures quiescent conditions for effective settling of suspended solids. Considering, the volume required for sludge and scum, septic tanks are designed with liquid holding times of 2 days (CPHEEO).

Septic tanks are normally rectangular in shape with a length to breadth ratio of 2 – 3:1. The liquid depth in the tank will be 1 – 2m.When the capacity of the tank exceeds 2,000 litres, the tank may be divided into two chambers, with the capacity of the first chamber twice that of the second chamber. Two compartment septic tanks have been found to be more effective with lower solids concentration in the treated effluent.

For systems providing treatment to population of over 100, two tanks shall be operated in parallel, with each handling half the designed flow.

Septic Tank Construction (BIS & CPHEEO)

Floor – The floor of the tank should be water tight and of sufficient strength to bear the weight of the tank walls and the septic tank contents. The floor should have a minimum slope of 1:10 sloping towards the sludge outlet to facilitate easy removal of sludge.

Walls: The walls could be of brick work with a minimum thickness of 200 mm and should be plastered to a minimum thickness of 12mm on the inside and outside. The walls should be water tight and have adequate strength to withstand the force and pressure of the liquid.

The inlet and outlet should not be located at such levels where the sludge or scum is formed to prevent disturbance of the scum or sludge by the liquid entering or leaving the tank. The inlet and outlet should be located as far away as possible from each other and at different levels to avoid short circuiting of the liquid. Baffles, provided at the inlet and outlet of the tank aid to distribute the flow evenly across the width of the tank. Baffles should dip 25 to 30 cm into the liquid and project 15 cm above the liquid surface. A ventilation pipe should be provided which should extend 2 m above the height of tallest building within a radius of 20 m. The top of the ventilation pipe should be covered with a suitable mosquito proof wire mesh.

Water-tightness

Watertight tanks are a necessity for the protection of the environment and for the operation of the system. Each tank should be tested for water-tightness and structural integrity by filling the tank with water before and after installation. Hydrostatic testing is conducted at the factory by filling the tank with water and letting it stand for 24 hours. If no water loss is observed after 24 hours, the tank is acceptable. Because some water absorption may occur with concrete tanks, the tank should be refilled and allowed to stand for an additional 24 hours. If the water loss after the second 24-hour period is greater than 1 gallon the tank should be rejected (ASTM C1227 (Precast Concrete Septic Tanks)). It is important that the above procedure be repeated once the tank is installed.

Design considerations

Detention time: 24 to 48 hours

Length to width ratio: 2:4

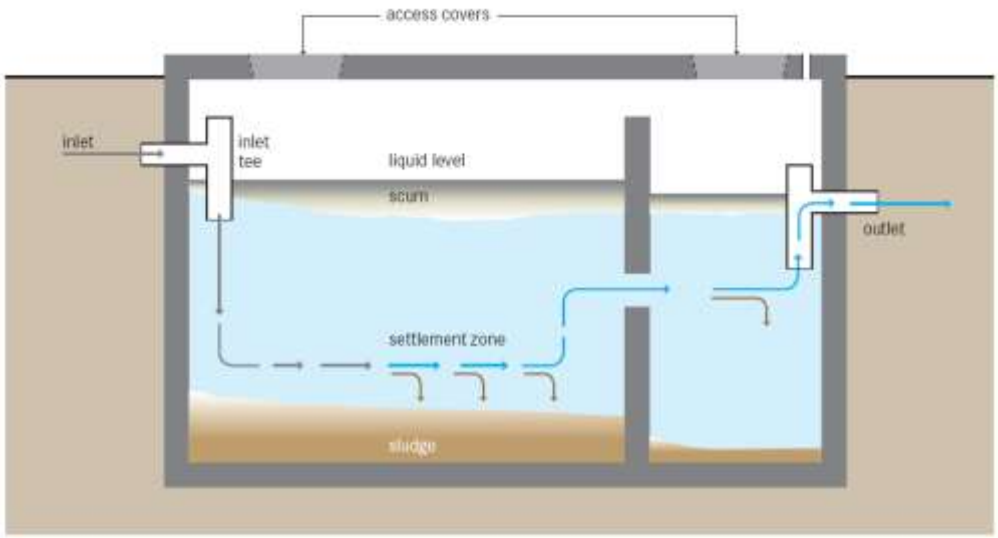
Liquid depth: 1 to 2 m

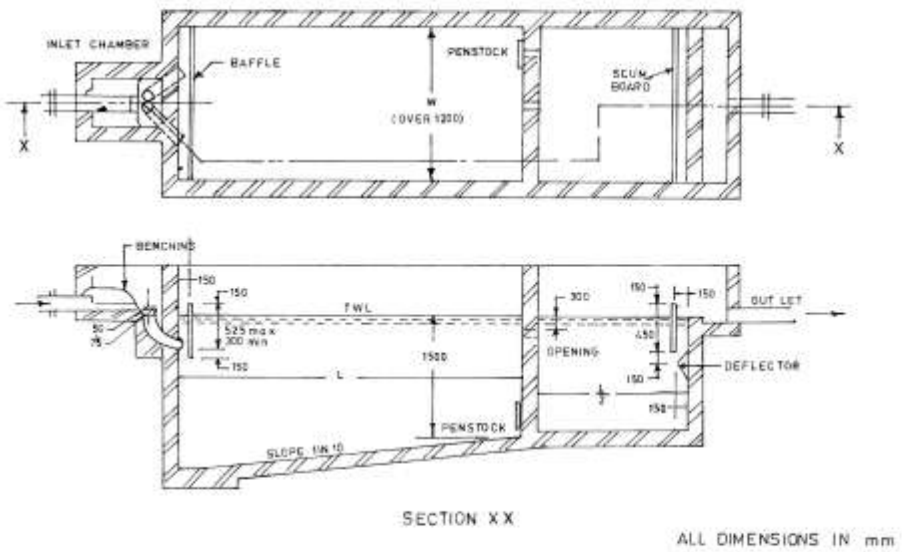
Recommended size of septic tank

No. of users	Length (m)	Breadth (m)	Liquid depth (cleaning interval of)	
			2 years	3 years
5	1.5	0.75	1.0	1.05
10	2.0	0.90	1.0	1.40
15	2.0	0.90	1.3	2.00
20	2.3	1.10	1.3	1.80
50	5.0	2.00	1.0	1.24
100	7.5	2.65	1.0	1.24
150	10.0	3.00	1.0	1.24
200	12.0	3.30	1.0	1.24
300	15.0	4.00	1.0	1.24

A provision of 300 mm should be made for freeboard.

Application Level	Management Level	Inputs: Blackwater, Greywater / Outputs: Faecal Sludge, Effluent
★★ Household	★★ Household	Inputs: Blackwater Greywater
★★ Neighbourhood	★★ Shared	
City	★★ Public	Outputs: Faecal Sludge Effluent





The septic tank effluent will contain suspended solids, dissolved organics and pathogenic organisms and hence need to be treated prior to its disposal. CPHEEO and BIS recommend the following methods for the treatment and disposal of septic tank effluents:

i. Soil absorption system,
ii. Biological filter, and

iii. Upflow anaerobic filters.

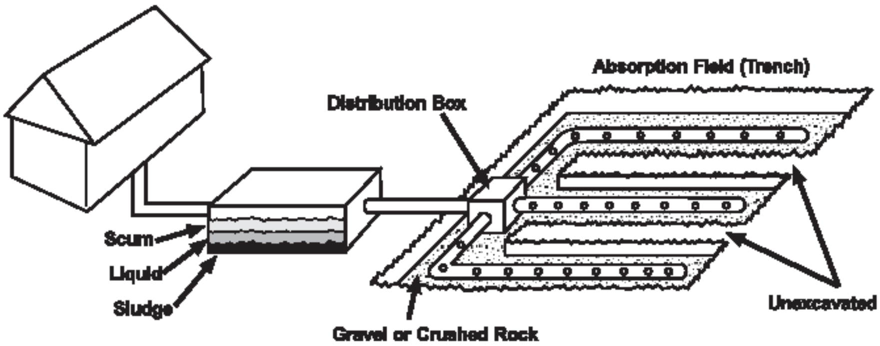
The choice of the treatment system is influenced by the position of the groundwater table below the soil surface, soil and sub-soil conditions and is presented in the table below (Indian Standards: 2470 (part 2) – 1985:

Position of the subsoil water level from the ground level	Soil and subsoil condition		
	Porous soil with percolation rate		Dense and clay soil with percolation rate exceeding 60 min
	Not exceeding 30 min	Exceeding 30 min but not exceeding 60 min	
Within 1.8 m	Dispersion trench located partly or fully above ground level in a mound	Dispersion trench ~~loacted~~ located partly or fully ~~abobe~~ above ground level in a mound	Biological filter partly or fully above ground level with underdrains or upflow anaerobic filter and the effluent led in a surface drain or used for gardening
Below 1.8 m	Seepage pit or dispersion trench	Dispersion trench	Subsurface biological filter with under drains or upflow anaerobic filter and the effluent led into a drain or used for gardening

Soil Absorption Systems

Normally soak pits or dispersion trenches are provided for further treatment of septic tank effluent. As land disposal methods rely on subsurface percolation or seepage into soil, their efficacies are influenced by the porosity and percolation characteristics of the soil. In addition the level of water table, the climatic condition, presence of vegetation and concentration of suspended solids in the effluent also influence the application of these systems. Soak pits or dispersion trenches can be used in all porous soil where the soil percolation rate is below 25 minutes/cm and the depth of the water table is 2 m or more from the ground level. Soak pits are cheap to construct and are widely used. When land available is limited and the water table is sufficiently below ground level, and when a porous layer rests over an impervious layer which permits downward flow, soak pits should be adopted. Soak pits are usually circular or square with minimum horizontal dimension of 1.0 m and a depth of atleast 1.0 m below the invert level of the inlet pipe. The pit may be lined with stone, brick or concrete blocks with dry open joints which should be backed with atleast 75 mm of coarse aggregate. A masonry ring may be provided at the top of the pit to prevent flooding of the pit by surface run-off.

Dispersion trenches should be preferred in soils with percolation rate between 12 and 25 minutes, if adequate land is available. In case of high water table, the dispersion trenches should be located partly or fully above ground in a mound. Dispersion trenches are narrow and shallow trenches about 0.5 to 1.0 m deep and 0.3 to 1.0 m wide with a gradient of 0.25%. Open jointed earthenware pipes of 80 to 100 mm size are laid in trenches over a bed of 15 to 25 cm gravel. The top of the pipe shall be covered by coarse gravel to a minimum depth of 15 cm and the balance filled with excavated earth and finished with a mound above the ground to prevent direct flooding of the trenches. The effluent from the septic tank is led into a small distribution box from which several trenches could radiate out. Each dispersion trench should not be longer than 30 m and the trenches should not be placed closer than 2.0 m from each other.



Location of subsurface absorption system – The location of the subsurface system is dependent on the percolation capacity of the soil. Bureau of Indian Standards (BIS) recommends that dispersion systems be located 18 m away from any drinking water source.

Design of soak pits and dispersion trenches: The permissible rate of application of effluent per unit area of dispersion trench or soak pit is governed by the percolation rate of the soil. The maximum rate of effluent application rates for few percolation rates are presented below (IS: 2470 (Part2) – 1985):

Percolation Rate (min)	Maximum Rate of Effluent Application (l/m^2/day)
1 or less	204
2	143
3	118
4	102
5	90
10	65
15	52
30	37
45	33
60	26

It should be also pointed out that if the percolation rate exceeds 30 minutes it is unsuitable for soakaways and should the percolation rate exceed 60 minutes, the soil would be unsuitable for any soil absorption system.

Biological filters: are adopted under conditions when the soil is impervious, water logged areas or there is limited availability of land. Microbes attached to the surface of the media facilitate the degradation of the organic matter in the effluent.

Upflow anaerobic filter: This method of treatment is recommended in areas with high water table, unfavourable soil conditions and limitation of space. A support medium is normally provided for the growth of microbes and under anaerobic condition prevailing in the tank, the anaerobic bacteria degrade the organic matter in the waste.

The volume of the anaerobic filter is determined by the organic loading rate and / or hydraulic retention time. Typical loading rates range between 0.3 – 1.2 kg COD/m^3.day and hydraulic retention time vary between 0.5 to 1.5 days.

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A thorough understanding of the soil is crucial for the success of any land disposal systems. Failure of many septic tank systems has been attributed to the poor attention to soil conditions in the design of these systems. Soil characteristics of relevance are detailed below:

Soil	
Texture	Soils with sandy or loamy textures are best suited. Gravelly and cobbley soils with open pores and slowly permeable clay soils are less desirable
Structure	Strong, granular, blocky or prismatic structures are desirable. Platey or unstructured massive soils should be avoided.
Colour	Bright uniform colours indicate well drained, well aerated soils. Dull, gray or mottled soils indicate continuous or seasonal saturation and are unsuitable.
Layering	Soil exhibiting layers with distinct textural or structural changes should be evaluated carefully to ensure water movement will not be severely restricted.
Unsaturated depth	0.6 to 1.2 m of unsaturated soil should exist between the bottom of the disposal field and the seasonally high water table or bedrock.

Septage is the semi-liquid material removed from the septic tank and is made of solids that have settled to the bottom of the septic tank, liquid and scum layer. Grit, oil and grease, solids and organics are the constituents of septage. The septage characteristics are as detailed below (U.S. EPA 1984):

Parameter	Concentration (mg/l)	
	Average	Range
Total solids	34106	1132 - 130475
Total volatile solids	23100	353 - 71402
Total suspended solids	12862	310 - 93376
Volatile suspended solids	9027	95 - 51500
BOD	6480	440 - 76600
COD	31900	1500 - 703000
TKN	588	66 - 1060
NH3-N	97	3 - 116
Total P	210	20 - 760
Alkalinity	970	522 - 4190
Grease	5600	208 - 23368
pH	1.5 – 12.6	1.5 – 12.6

Decentralised wastewater treatment system (DEWATS)

The decentralised wastewater treatment system (DEWATS) is a simple design, non-dependent on energy, reliable, long-lasting, tolerant towards inflow fluctuation, and low in costs. It can treat organic wastewater from domestic and industrial sources. DEWATS is based on different natural water treatment techniques which are combined according to requirements such as the characteristics of wastewater, desired effluent quality and technical specifications.

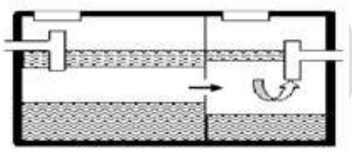
Key features of DEWATS are as follows:

- Treatment of a wide range of wastewater types at affordable prices
- Fulfilment of discharge standards and environmental laws
- Treatment of wastewater flows from 1-1000 m³ per day
- Tolerance to inflow fluctuation
- Resource efficiency and non-dependence on energy
- Minimal maintenance
- Reliability and longevity
- Re-use of wastewater and its by-products such as biogas and sludge
- Does not require deep sewer line construction
- Can be integrated into the landscape
- Combinations of aerobic and anaerobic treatment process. The anaerobic modules comprise of settlers, baffle reactors and anaerobic filters. The aerobic modules have horizontal planted gravel filters and a polishing pond.

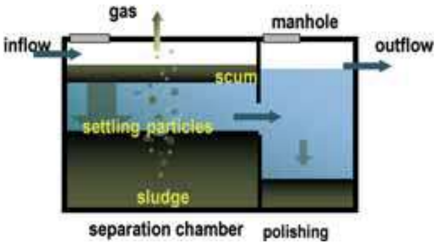
DEWATS modules description

Primary Treatment (Pre treatment)

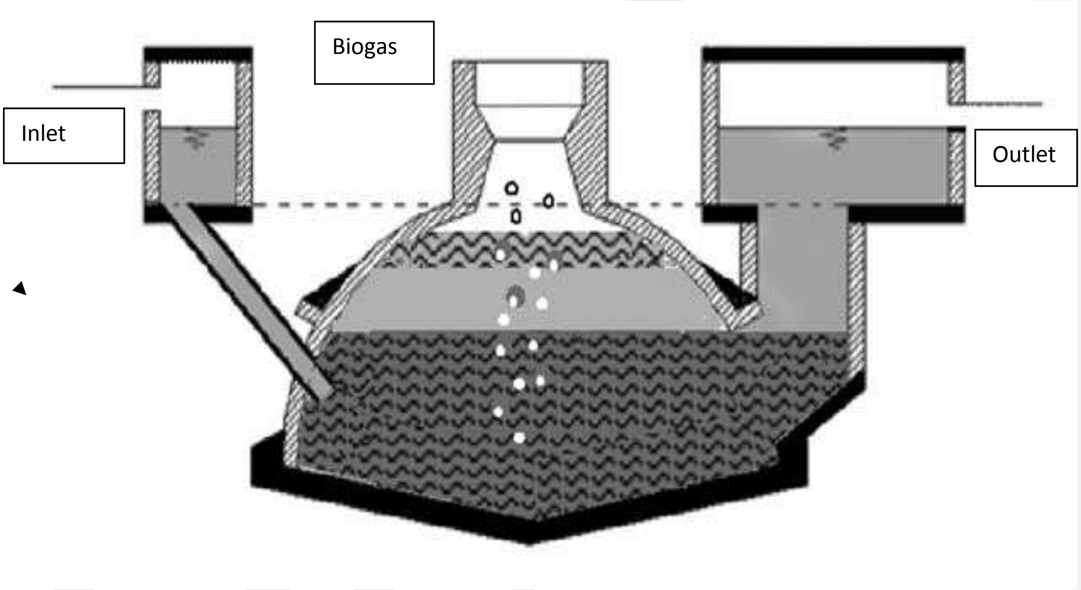
1. Grease traps are used as pretreatment steps to retain oil and grease by flotation, while clearer water underneath is discharged in to the following treatment module. The wastewater is retained in this unit for 2 to 4 minutes.



2. Settlers are sedimentation tanks for retaining all that sinks in a given time. Settled (sunk) organic matter is retained in the tank, while all the rest (dissolved and suspended matter) passes untreated to the following treatment module. The wastewater is retained in this unit for 1.5 to 2 hours.

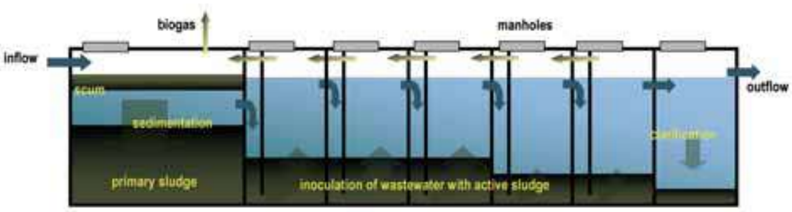


3. Biogas settlers are sedimentation tanks for retaining all that sinks (settles) in a given time. Biogas is formed due to the decomposition (digestion) of settled organic particles; called anaerobic digestion. All the rest (dissolved and suspended particles) pass untreated to the following treatment module. The wastewater is retained in this unit for 12 to 24 hours.



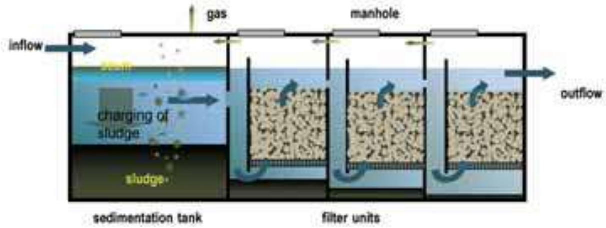
Secondary treatment

1. Baffle reactors ensure anaerobic degradation of suspended and dissolved solids by mixing wastewater with active sludge blanket – these are naturally occurring bacteria that accumulate in the bottom of each chamber. The baffle reactor is suitable for all kinds of organic wastewater and its efficiency increases with more organics in the water (the dirtier the better). The wastewater is retained in this unit for 1 to 2 days.



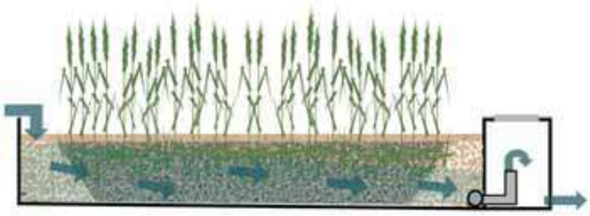
2. Anaerobic fixed bed filters make use of anaerobic digestion process with fixed bed filter—these are stones or other material in chambers. Active bacterial mass grows on the filter material (carrier). These units treat whatever is dissolved in the wastewater by bringing

it in close contact with active bacteria mass. The filter media can be cinder, rock aggregates, slag, or specially designed plastic material etc. These units are ideal for wastewater with low content of suspended solids. The wastewater is retained in this unit for 1.5 to 2 days.



Tertiary treatment

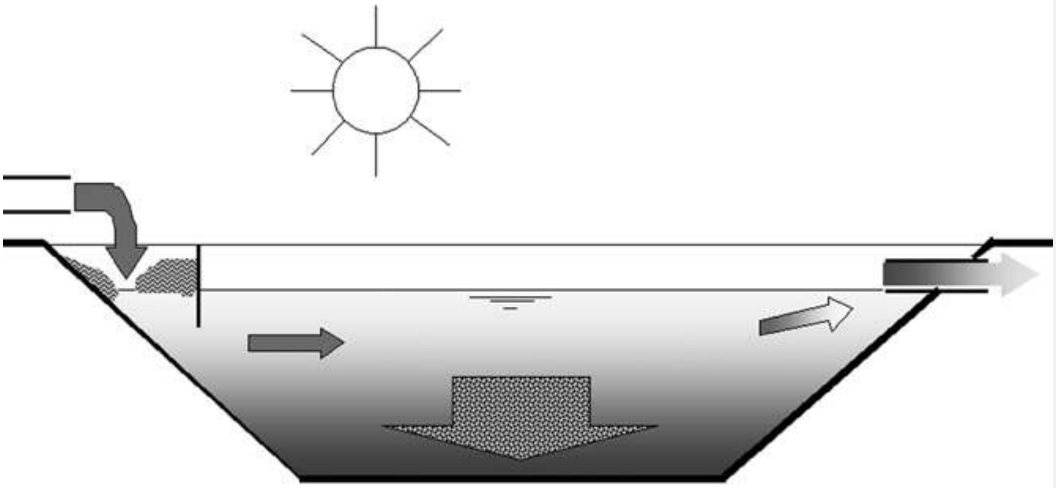
1. Horizontal Planted Gravel Filter: The horizontal gravel filter is a shallow tank filled with graded gravel or pebbles, and special plants are planted in this gravel filter. The normal depth is 60cm. The main removal mechanisms are biological conversion, physical filtration and chemical adsorption. Plants commonly used are canas indica, reed juncas, phragmites etc. The filters clean the wastewater by retaining particles and digesting them with the help of bacteria growing naturally on the gravel/ pebbles. Important is the intake of air (oxygen) into the filter body. The plants help with transporting oxygen through their roots. Wastewater is retained in this unit between 5 to 10 days.



Post Treatment

1. Polishing Pond: The polishing pond is a shallow pond where pathogen removal takes place. The main purpose of ponds is oxygen enrichment and elimination of pathogen germs through sun’s radiation. Floating aquatic plants can help control algal growth and make it a

pleasant landscape feature if desired. Wastewater is retained in this unit for 1 day.



7. Safe Collection, Handling and Transport of septage from on-site installation

The NUSP underlines the necessity for safe confinement and treatment of human excreta. Thus, it is not only important to ensure that installations confine excreta safely but also that handling of septage is done in order not to put sanitary workers and residents to risks. Finally, care should be taken to ensure that the septage is transported safely to the treatment and disposal site.

The National Building Code of India states that septic tanks should be regularly maintained and desludged as often as every year. "Septic tanks should be cleaned when a large quantity of septage has collected in the bottom of the tank. The interval of cleaning should not normally exceed 12 months. After cleaning, three or four shovelful of surface earth containing grass roots and decaying vegetable matter should provide a good start. No disinfectants should be used in latrines attached to septic tanks as they kill the organisms, which digest sewage."

ULBs/Utilities will need to ensure that handling, transport and disposal are in compliance with the Environment Protection Act, the Water Act, and the Municipal Solid Waste Management (Handling) and Management Rules.

Safety Gear: The ULB or the Utility will need to prepare a list of safety gear for sanitary workers and notify this under the appropriate Municipal Rules. This must list out mandatory items including masks, gloves, boots, overalls of appropriate material and quality that will need to be used by all sanitary workers i.e. whether in public institutions or privately employed, who are responsible for handling fecal matter or septage or sewage. In addition, a list of precautions and standard operating procedures are also recommended to be notified.

The ULB / Utility will need to budget for the above purchases and ensure that workers are

Safety Concerns

Operating septage pumping equipment is dangerous. Operators are responsible for their personal safety as well as safety on the road. Septage is infectious material. It can cause disease if ingested or if it comes in contact with broken skin. Hands must always be washed immediately after contacting septage or tools and equipment that may have contacted septage, and always before eating or drinking.

Septage workers should be immunized for tetanus, hepatitis A, and hepatitis B. Smoking must be prohibited while operating septage equipment. Septic tanks may generate methane, an explosive gas. Smoking also promotes the hand-to-mouth route of infection. Caution must be used around septic tanks and septic tanks must never be entered. People are killed every year in septic tanks, because tanks are confined spaces that may contain toxic or oxygen-limited atmospheres. Septic tanks also may collapse or break if excessive weight is place on the lid or manhole cover.

trained to use the safety gear and are strictly monitored that they do so.

The ULB / Utility will need to monitor that the private sector cleaning services companies are also adhering to occupational health and safety standards notified, and offenders will need to be fined and other punitive actions invoked.

Tools/Methods and Equipment: The ULB / Utility will recommend a list of the common tools to be used for monitoring the septic tanks. This include sticks that are used to assess effluent turbidity to more sophisticated methods like testing samples for COD, BOD, TSS, Coliforms, nitrate that can be used for medium-range planning.

Standard Operating Procedures for Pumping and Desludging Septic Tanks

The sludge level in septic tanks is determined by the use of a probe on a long handle that the operator submerges into the tank and feels for the sludge level. This is a very accurate way to gauge sludge depths. Comprehensive programs that provide annual inspections and pumping as needed may be more advantageous then prescribing mandatory pumping on a set schedule. This is true especially for programs with limited septage treatment or hauling capacity. There are many benefits associated with routine and periodic septic tank desludging, including:

Increased Efficiency: Septic tanks work best when detention time in the tank is maximized. As accumulated sludge reduces available tank volume, the resulting decrease in detention time impacts the tank's function and ability to separate heaver solids from lighter fats and oils.

Higher Discharge Quality: Septage has a much higher concentration of pollution constituents then septic tank effluent. Biochemical Oxygen Demand (BOD) and total suspended solids (TSS) are two common measurements of the strength of wastewater. Septage may have BOD concentrations between 2,000 and 20,000 mg/l and TSS values in excess of 50,000 mg/l, where septic tank effluent has values averaging 200 mg/l BOD and 300 mg/l TSS. As septic tanks fill with sludge, the effluent begins to resemble septage with dramatically higher pollution values. *Therefore, regular desludging provides dramatic improvements in effluent quality*.

How Often To Pump: Ideally, septic tanks should be pumped only when necessary. On average, the septic tanks should be pumped every two to three years. Unnecessary pumping places an undue burden on pumping, transpiration, treatment and disposal facilities. Since families generate varying volumes of sludge at different rates, pumping programs that focus on routine inspection and pumping when required, rather than mandated periodic pumping, are most efficient.

Prior to sending the septage truck to a neighbourhood for desludging activities, service providers may consider sending an advance crew to the area to inform homeowners of the pumping activities, to locate septic tank manholes and access ports, and probe tanks to determine the level of accumulated sludge.

This activity will identify which tanks require pumping, and which may wait until the next cycle. Ideally, septic tanks should be pumped when needed based on the volume of accumulated sludge (standard practice in India is to desludge every two years or so). Community run education programs, such as distributing flyers about the proper care and maintenance of septic tanks would also build awareness and help inform people.

Specific procedures for pumping, and the transportation activities of the septage management program should be specified in a Manual of Practice. The Septage Program Managers should prepare a Manual of Practice by first reviewing the operations procedures for specific equipment and then documenting all aspects of the day-to-day procedures. These procedures include:

- Scheduling and routing for trucks
- Customer service protocols
- Locating tanks and cleanouts
- Proper pumping equipment operation and worker safety
- Site control, including post-pumping clean-up
- Transportation requirements, including rules of the road
- Disposal procedures at the treatment facility
- Routine service of equipment – greasing and oiling, minor repairs
- Recordkeeping for all tanks pumped and wastes discharged at the disposal facility

As each program is different and utilizes different equipment, the Manual of Practice is program-specific. A Manual of Practice is an important document since it provides guidance for the equipment operators. Furthermore, it is a valuable a training document for new employees. The Manual can specify set procedures that employees should follow so that their work is done within specified guidelines. The procedures should be recorded in a step-by-step field manual that becomes an addendum to the septage management regulations.

Recordkeeping and Manifests

Keeping accurate records regarding tanks and volume pumped is important for billing and compliance. Recordkeeping and manifest forms are an integral part of a comprehensive septage management program. Recordkeeping requirements should be codified into the law governing the program. Manifest forms are simple receipts that specify:

- the location or address of the pumped septic tank
- septage characteristics (residential or commercial)
- the name and address of the property owner or occupier
- the volume of septage pumped
- any notes regarding tank deficiencies, missing pipes or fittings, improper manholes or access ports, any other cracks or damage observed

Once completed, a copy of the manifest is given to the owner as a receipt. When the load is delivered to the disposal site, the disposal site operator:

- accepts the load
- verifies the volume
- takes a sample if needed
- signs the manifest proving receipt of the volume of septage disposed of

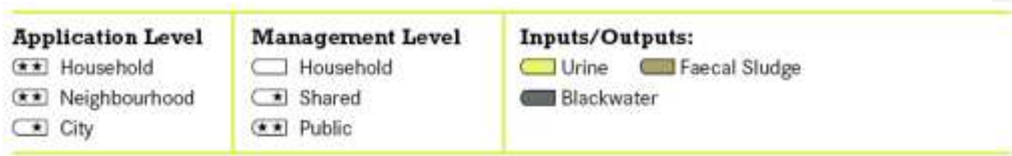
It may be advantageous for the operator to pump out multiple tanks before going to the disposal site. In this case, a multiple-load manifest form should be completed as well as individual manifest/receipt forms. The completed document or documents should be given to the local government for their records. The manifest system is a tracking and compliance tool. It helps ensure that all of the septage pumped arrives at the disposal site and minimizes the opportunity for illegal discharge. It is also a record that some septage programs may choose to use for paying septage hauling subcontractors. For example, Manila Water Company pays its hauling contractors based on the cubic meters of septage delivered to the disposal site as recorded on the manifest. This system accomplishes two main goals. First, it provides an incentive for haulers to make proper disposal at the treatment facility. Second, it provides an incentive for the pumper to pump as much volume out of the septic tank as possible. This is important since simply removing the liquid fraction of the septic tank doesn't remove the sludge, which is the fundamental goal of the pumping service.

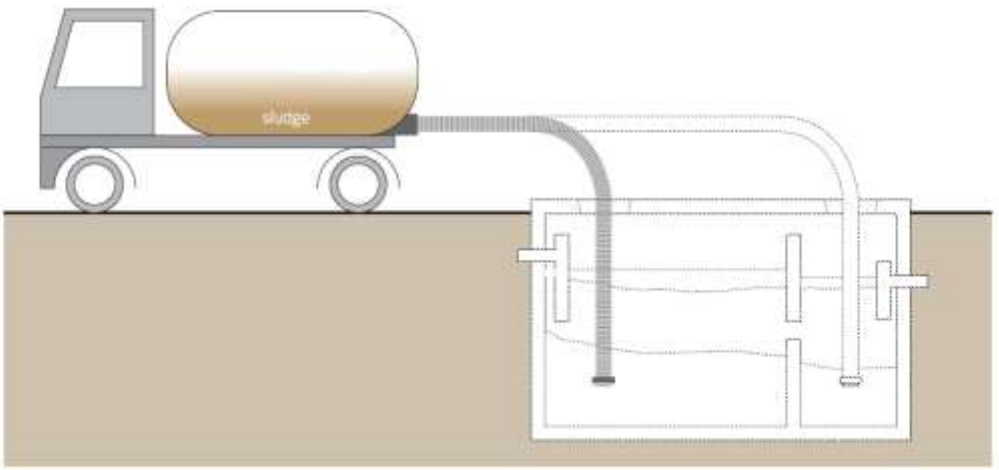
Motorised Emptying and Transport

Motorized Emptying and Transport refers to a vacuum truck or another vehicle equipped with a motorized pump and a storage tank for emptying and transporting faecal sludge, septage and urine. Humans are required to operate the pump and manoeuvre the hose, but they do not lift or transport the sludge.

The pump is connected to a hose that is lowered down into a constructed tank (e.g. septic tank or aquaprivy) or pit, and the sludge is pumped up into the holding tank on the truck. Generally the storage capacity of a vacuum tanker is between 3,000 and 10,000L. Multiple truckloads may be required for large septic tanks.

Both the agencies responsible for sewerage and private entrepreneurs may operate vacuum trucks, although the price and level of service may vary significantly. Some public operators may not service informal settlements, whereas some private operators may offer a reduced price, but can only afford to do so if they do not empty the sludge at a certified facility. The cost of hiring a vacuum truck can sometimes be the most expensive part of operating a sanitation system for some homeowners.





The Vacutug consists of a 0.5 m³ steel vacuum tank connected to vacuum pump which is connected to a gasoline engine. On level ground, the vehicle is capable of around 5km/h. The waste sludge can be discharged under gravity or by slight pressurization from the pump. Recent results indicate that under certain circumstances (constant number of pits, transfer station, short transfer distance, etc.) the Vacutug can be sustainable and cover its operating and maintenance costs.

Adequacy Although smaller more mobile vehicles have been developed, large vacuum trucks remain the norm for municipalities and sanitation authorities. Unfortunately, large trucks cannot access all pits/septic tanks especially in areas with narrow or non-driveable roads. Also, vacuum trucks can rarely make trips to peri-urban or rural areas since the income generated from emptying, may not offset the cost of fuel and time.

Depending on the collection or treatment technology, the material that needs to be pumped can be so dense that it cannot be pumped easily. In these situations it is necessary to thin the solids with water so that they flow more easily, but this may be inefficient and costly. If water is not available, it may be necessary for the waste to be manually removed. In general, the closer the vacuum can be to the pit, the easier it is to empty. The critical velocity of the sludge required for pumping is dependent on the distance from, and strength of, the vacuum pump; sludge is extremely site specific. Garbage and sand also makes emptying the pit much more difficult.

Health Aspects/Acceptance The use of a vacuum tanker for emptying a pit latrine or septic tank presents two health improvements: (1) emptying maintains the Collection and

Storage/Treatment technology and reduces the risk of overflows and (2) the use of a tanker reduces the need for manual emptying, which is quite unsafe and unhygienic. Still, those who operate vacuum trucks may be demonized by the community and may face difficulties with finding appropriate locations to dump and treat the collected sludge.

Maintenance is a crucial part of vacuum truck operation. Trucks are not usually brand new and they often require constant attention to prevent breakdowns. The lack of preventive maintenance is often the cause for major repairs.

Most pump trucks are manufactured in North America or Europe. As such, it is difficult to locate spare truck parts and a local mechanic to repair broken pumps and trucks. New trucks are difficult to obtain, very expensive and thus rarely purchased. Local trucks are commonly adapted to serve as vacuum trucks by equipping them with holding tanks and vacuums. Maintenance accounts for at least one quarter of the costs incurred by the operator of a vacuum truck. Fuel and oil account for another quarter of the total operating costs. Owners/operators must be conscientious to save money for the purchase of expensive replacement parts, tires and equipment, whose replacement could be essential to the working of the vacuum truck.

8. Options of different treatment methods of Septage

Septage treatment: The commonly employed methods for the treatment and disposal of septage are treatment at sewage treatment plant, land treatment and composting.

Treatment at sewage treatment plants: An effective option, wherever treatment plant exists and the distance to the treatment plants are not very significant. As septage characteristics are similar to domestic wastewater, albeit a bit stronger, and as the volume of the septage as compared to the wastewater flowing to the treatment plant is low, it can be readily treated in the wastewater treatment plant. Septage, could be either combined with the sewage and treated (before the screen and grit removal systems) or could be treated along with sludge in sludge treatment units in the sewage treatment plant.

Land treatment: is the widely adopted method for the treatment of septage in the U.S. Simple and cost effective, land application approaches use minimal energy and recycle nutrients back to the land. Topography, soils, drainage patterns, and agricultural crops determine which type of land disposal practice works best for a given situation. Some common alternatives are surface application, subsurface incorporation, and burial. When disposing of septage by land application, appropriate buffers and setbacks should be provided between application areas and water resources. Other considerations include vegetation type and density, slopes, soils, sensitivity of water resources, climate and application rates. Sunlight, soil microorganisms and desiccation combine to destroy pathogens and many toxic organic substances found in sludge. Trace metals are trapped in the soil matrix and nutrients are taken up by the plants. Spetage could also act as a soil conditioner to facilitate nutrient transport, increase water retention and improve soil tilth. Land application practices include the following:

Spreading by hauler truck or farm equipment – in this method the truck that empties the septage takes it to the field and spreads it on the soil.

Spray irrigation – septage is pumped at 80 – 100 psi through nozzles and sprayed directly onto the land. This allows the septage to be disposed on fields with rough terrain and also eliminates the problem of soil compaction by the truck tyres.

Ridge and furrow irrigation – septage can be directly transferred to furrows or row crops.

Subsurface incorporation of septage – This alternative to surface application involves placing untreated septage just below the surface. This helps reduce odours and health risks while still fertilizing the soil. The method can be applied only on relative flat lands (less than 8% slope) and in areas where the seasonally high water table is at least 20 inches. Because soil compaction is a concern, no vehicles should be allowed to drive on the field for 1 to 2 weeks after application. Subsurface application practices include:

Plow and furrow irrigation – in this method a plow creates and a narrow furrow 6 to 8 inches deep. Liquid septage is discharged from a tank into the furrow, and a second plow covers the furrow.

Subsurface injection: A tillage tool is used to create a narrow cavity 4 to 6 inches deep. Liquid septage is injected into the cavity and the hole is covered.

Composting

Composting is another popular method of treating septage. Compost is defined as “the stabilization of organic material through the process of aerobic, thermophilic decomposition.” During the composting process organic material undergoes biological degradation to a stable end product. Approximately 20 percent to 30 percent of the organic solids are converted to carbon dioxide and water. As the organic material in the septage decomposes, the compost heats to temperatures in the range of 50 to 70 degrees Centigrade and harmful pathogens are destroyed. The resulting humus-like material is suitable as a soil conditioner and source of nitrogen and phosphorus. Septage can be composted directly. The basic procedure for composting is as follows:

1. Septage or wastewater solids are mixed with a bulking agent (e.g. wood chips, sawdust) to decrease moisture content of the mixture, increase porosity, and assure aerobic conditions during composting.
2. The mixture is aerated either by the addition of air (“aerated static pile”) or by mechanical turning (“agitated”) for about 28 days.

The most common “agitated” method is windrow composting: the mixture of septage or wastewater solids and bulking agent is pushed into long parallel rows called “windrows”, about 1 to 2 meters high and about 2 to 4.5 meters at the base. The cross-section is either trapezoidal or triangular. Several times a week the mixture is turned over. Although specialized equipment has been developed for windrow composting, it is possible to use a front-end loader to move, push, stack, and turn the mixture. Factors affecting the composting process (US EPA 1984) include moisture content (40 percent to 60 percent); oxygen (5 percent to 15 percent); temperature (must reach 55 to 65 ^{o}C); pH (6 to 9); and carbon-to-nitrogen ratio (30 to 1).

For effective operations there should be sufficient laboratory equipment to monitor these parameters during the compost process. Moisture can be added and turning can be increased based on monitoring results. The operator should measure temperature at least once per day by placing a thermometer into the mixture at various locations. Maintaining temperature of 50 to 60 ^{o}C for the compost period assures destruction of pathogens. Co-composting septage or wastewater solids with the organic fraction of municipal solid waste is possible. The organic fraction includes food wastes, paper, and yard-wastes (e.g. leaves, branches, shrubbery, etc. cut or removed during landscaping). The MSW serves as the bulking agent.

Compost from septage or wastewater solids can be used as a soil amendment to reclaim land or used in landscaping or horticulture. Agricultural use or use that may include human contact (e.g. at parks or playgrounds) requires detailed laboratory analysis to confirm concentrations of pathogens and heavy metals are within safe limits. In order to produce treated septage of suitable quality for soil amendments, limiting septage collection to residential housing is required.

Drying beds: could be used to dewater septage. They are simple and easy to operate, low cost and require minimum operator attention. When sludge is deposited on a well drained bed of sand and gravel, significant amounts of water drain rather quickly following which evaporation aids in the frying process. The sludge cake shrinks and cracks which further hastens evaporation from the surface. In areas having greater sunshine, lower rainfall and low humidity, the drying time could be about two weeks, while it could be four weeks in other areas. Weather, septage characteristics and the time for removing the dried sludge are the factors that influence the design of seepage systems. High temperature and high wind velocity hasten the drying process while high humidity and precipitation retard drying. A typical sand drying beds consists of 300 mm of fine sand underlaid by 200 to 460 mm of gravel. The sand should have an effective size of 0.3 to 0.75 mm, be clear of any fines, and have a uniformity coefficient less than 3.5. The gravel size should be 2.5 to 25 mm. Underdrains are usually vitrified clay pipes or tiles of at least 100 mm diameter laid with open joints. Septage is applied to a depth of 0.3 m on the drying beds and a drying cycle of 10 days is normally followed between two septage applications. The drying beds are typically of size 6m (length) x 6m (width).

9. Planning for Septage Management

How to do Population Projections

Box: Septage generation rate
Septage generation rates vary widely from place to place depending on septic tank use practices, number of users, water used for flushing, efficient functioning of the tank and contamination control. It can be considered that the volume of sludge evacuated from a septic tank corresponds more or less to the volume of the septic tank, plus some cleansing and rinsing water. The size of a septic tank in individual houses in India ranges from 1 to 4 m3, the size of a septic tank in office or apartment buildings from 10 to 100 m3. The following estimations and assumptions can be used for the purpose of this guideline, which can be adjusted to the local requirements:

· One septic tank per 4 inhabitants
· Average volume of septage produced through emptying of a septic tank by vacuum tanker: 2.5 m3.
· Emptying frequencies, which are in accordance with septic tank design (5-10 years intervals)

will be observed
· Assuming there are 2500 houses in a town having individual septic tank.
· Number of houses served each year = 2500/5= 500
· Assuming septic tanks are emptied during 250 days (working days)/year or 500/250 = 2 tanks/d
· Total volume of septage in a day would be 2.5*2 = 5 m3
· BOD loading would be 2,800*5 = 14 kg/d
· SS loading would be 15,000*5 = 75 kg/d
(*) stands for multiply

Source: CSE, 2010

10. Regulation and Monitoring by ULB/City Utilities

There are no specific legal provisions relating to urban sanitation or septage management but there are a number of provisions relating to sanitation services (CSE, 2010). Municipal Acts and Regulations usually refer to management of solid and liquid wastes but may not provide detailed rules for septage management. Therefore, it is recommended that ULBs formulate their own bye-laws and rules for management of septage in the city – this could be taken up as a State-level activity in consonance with the Municipal Act in place.

The state and appropriate development authorities would need to review the building regulations to ensure proper construction of adequate on-site facilities for loads projected to be generated and ensuring safe disposal. These will need to be disseminated to the construction industry and households through periodically scheduled interactions like workshops. Sites selected for sludge application by the ULB and by other parties (like residential layouts) would need prior consent to operate from the competent authority (like the PCB).

The Rules should address:

- Design of Septic tanks, pits etc. (adapted to local conditions) and methods of approval of building plans, or retro-fitting existing installations to comply with rules
- Special provisions for new real estate developments
- Periodicity of de-sludging, and O&M of installations
- Operating procedures for de-sludging including safety procedures
- Licensing and reporting
- Methods and locations of transport and disposal
- Tariffs or cess/tax etc. for septage management in the city especially disposal
- Penalty clauses for untreated discharge: for households as well as de-sludging agents

The Environment (Protection) Act, 1986 and the Water (Prevention and Control of Pollution) Act, 1974 also apply to households and cities in terms of their disposing wastes in to the environment. ULBs/Utilities also have to comply with discharge norms for effluent released from sewage treatment plants and to pay water cess under the Water Cess Act, 1977. The ULB is responsible for ensuring the safe handling and disposal of septage generated within its boundaries, for complying with the Water Act, 1974 for meeting all state permit requirements and regulations (CSE, 2010).

The Septage Management Rules should provide for issuing licenses to private operators providing de-sludging services. All public and private sector staff should adhere to safety norms as provided in the Municipal Solid Waste (Handling) and Management Rules 1999, and such other safefguards that the ULB may provide under its own rules. For disposal of septage, the ULB will need to follow the standards set out in the Environment (Protection) Act, 1986, depending on the mode of disposal (CSE, 2010).

Inspection of onsite system and pumping of septic tanks: should be carried out by the ULB/Uility. Following the design norms adapted to local conditions that is notified under the Septage Management Rules, the ULB should carry out regular inspection of properties with on-site systems.

Baseline Data Collection: For any serious Septage Management Plan to be effective, robust data on septage arrangements, volumes and locations is required. The ULBs would need to make arrangements to collect baseline data – type of latrine disposal, effluent disposal arrangement, size, age, when it was last cleaned, availability of access, arrangement for disposal of effluent if any) of existing installations, to plan for workable desludging schedules. It is advisable to divide the city into working zones and carry out this baseline activity in one or a few of these zones, pilot desludging schedules by area to learn operational issues and devise solutions, before scaling up to the whole ULB area. The selection of zone could be based on availability of septage disposal sites – existing STPs could be potential septage disposal/application sites or trenches provided in solid waste landfill sites or suitable urban forestry sites where the septage trenches would serve to fertilise the plants. It is felt suitable that households in demarcated septage management zone.should be within a 30 km. travel distance from identified disposal sites, for workability.

The ULB will need to coordinate with existing service providers (if any) and ensure that collection, transport and disposal of septage is carried out in a manner safe to households, environment and public health. It would be advisable for the ULBs to set up a one-time registration mechanism for service providers with nominal fee. This would also build up a database of available facilities within designated service areas. Periodic interactions with the service providers would aid in improving the septage management process over time.

As described in earlier sections, appropriate record-keeping systems and reporting procedures will need to be set up for ULBs to track desludging schedules, through integration to the property tax database.

11. Financing of capital costs and O&M management

Financing of capital costs and O&M of Septage Management Systems in the city are very important elements of planning and successful operations. An illustration from Hoshangabad city in Madhya Pradesh is provided for norms and costing.

Septage Management (including treatment using sludge drying beds)

Under the fully on-site sanitation approach, no separate wastewater treatment facility will be necessary as all wastewater will be disposed on-site. Only the septage (septic sludge) will have to be safely removed for further treatment and final disposal. The septage clearance frequency is assumed to be once in 2 years and volume decanted per clearance is considered to be about 2 cubic meters

(Cum). Further it is assumed that each vehicle will clear 3 tanks per day and the vehicle will operate for 300 days per year [4]. (Table A.1)

Table A.1: Base Norms, Specifications and Assumptions		
No.	**Component**	**Norm** ***Unit***
A	**Household sanitation infrastructure**	
1	*Latrine connected to septic tank*	*1 per household*
2	*Grit and grease trap*	*1 per household*
B	**Septage Clearance, Treatment and Disposal**	
1	*No of septic tanks cleared per vehicle per day*	*3 tanks per day per vehicle*
2	*Frequency of septage clearance from septic tank*	Once in 2 years
3	*Septage volume removed per tank*	*2 cum*
4	*No of operational days per annum*	*300 days*
	Sludge Drying Beds	
5	*Area per drying bed(average)*	*225 m*
6	*Dimensions of drying bed*	*15m x 15 m*
8	*Thickness of liquid sludge layer in drying bed*	*0.20 m*
9	*Septage Sludge Drying Cycle*	*10 days*
10	*Sludge volume per bed*	*45 cum*
Source: Hoshangabad CSP Analysis, 2010		

In order to provide uninterrupted service to nearly 20,665 households that will be using septic tanks, about 11 trucks will be required, which would have to be operated for about 300 days every year to service all the households. These computations are provided in Table A.2.

Table (A.2) Computations: Septic Tanks cleared, septage volume and sludge drying beds	
Septage clearanc	• A total of 11 (***eleven***) septage clearance vehicles will be needed. The HNPP currently has one septage clearance vehicle

[4] The assumption is made considering that the Hoshangabad Nagar Palika will engage private service providers as well and that the services will be available to the household even on some of the holidays considering user convenience.

e vehicles	• To efficiently manage septage clearance, 10 (***ten***) additional vehicles will have to be purchased • *Out of this, 9 (**nine**) vehicles will be purchased in year-1, whereas 10th (**tenth**) vehicle can be purchased in year-4.*
Tanks cleared per year	$No\ of\ septic\ tanks\ cleared\ per\ year = 11\ trucks \times 3\ tanks \times 300\ days$ $No\ of\ septic\ tanks\ cleared\ per\ year = \mathbf{9,900}$
Daily septage volume	$Daily\ septage\ volume = 11\ trucks \times 3\ tanks \times 2\ cum/day$ $Daily\ septage\ volume = \mathbf{66\ m^3}$
Septage drying bed	$Single\ Drying\ bed\ area = 12 \times 12m$ $Single\ Drying\ bed\ area = 120\ m^2$ $Max.Septage\ depth = 0.30\ m = 30\ cm = 300\ mm$ $Capacity\ per\ bed = 36\ m^3$ $Daily\ requirement\ of\ beds\ (Nos) = 66\ m^3/36\ m^3$ $Daily\ requirement\ of\ beds\ (Nos) = 2$ • Considering a drying cycle of 10 days, a total of 20 drying beds are suggested
Indicative Site Area	$Total\ Site\ Area = SD\ bed\ area + 10\%\ of\ SD\ bed\ area + area\ for\ office\ and\ dried\ sludge\ storage + area\ for\ ancilliary\ units$ $Total\ Site\ Area = (2{,}880 + 288 + 5{,}000 + 2{,}250)\ m^2$ $Total\ Site\ Area = 10{,}418 m^2$
Source: Hoshangabad CSP Analysis, 2010	

The septage is proposed to be converted to sun-dried sludge cakes by dewatering on sand filter beds. Land requirement of about 10,500 m^2 (1.05 Hectare) has been estimated. Over most of the year, the septage drying time is expected to be about 7 days; however, an average of 10 days are considered to accommodate longer drying periods during the rainy season. A total of 20 drying beds are proposed, considering the longer drying time in the wet season. The sludge drying beds could possibly be located at the Solid Waste processing site.

Indicative Investment Requirements

Indicative investment requirements to construct the infrastructure are estimated based on the unit costs and estimated infrastructure quantities (Table A.3). Indicative estimates suggest that, over the CSP implementation period, households will have to invest about **Rs 155 million**. A little less than half of this investment will be for new construction of sanitation facilities. Households already having access to individual sanitation facilities will have to invest about Rs 29 million in upgrading. In order to increase coverage, more than Rs 52 million will be needed. Most of these households will be urban poor, needing financial assistance (in the form of either a subsidy or a soft loan).

Septage clearance equipment and construction of treatment facility is estimated to cost about Rs 15.84 million. This is excluding the cost of land required for septage treatment facility.

TABLE (A.3): CAPITAL AND OPERATION & MAINTENANCE COSTS OF SANITATION INFRASTRUCTURE						
No.	**Component**	**Capital Cost**		**Operation & Maintenance**		
		Unit	**Rate (Rs)**	**Unit**	**Rate (Rs)**	**Remarks**
B	**Septage Clearance and Treatment**					
1	Vacuum Trucks	Rs/vehicle	800,000	Rs/vehicle/ year	462,000	
2	Septage Sludge Drying Beds	Sqm	2,000	Rs/sqm /year	1,000	
3	Land	Hect				
4	Office and ancillary units	LS	1,500,000	Rs/ year	60,000	4% of Capital
5	Septic Tank Clearance charge			Rs/ HH	1,200	
6	Septic tank clearance (O&M cost)			Rs/ tank	560	

Notes:

1. The costs of infrastructure (except wastewater treatment) are based on information collected from various infrastructure projects implemented in Indian cities over 1998-2006. These costs were then extrapolated for 2009 prices.

* - The wastewater treatment costs are based on CDM (2005) report for Hyderabad Metro Water Supply and Sewerage Board (HMWSSB)

Source: Hoshangabad CSP Analysis, 2010

TABLE (4.6): COMPONENT-WISE INDICATIVE INVESTMENT REQUIREMENTS, O&M COSTS AND USER CHARGES								
No.	**Component**	**Unit**	**Year Wise Costs**					
			2010	**2011**	**2012**	**2013**	**2014**	***Total***
C.	**Septage Clearance and Treatment**							
i.	*Septic tank user households*	*Nos*	*17,735*	*18,275*	*18,877*	*19,552*	*20,310*	

No.	Component	Unit	Year Wise Costs					
			2010	2011	2012	2013	2014	***Total***
ii.	*Septic tanks cleared*	*Tanks/year*	8,868	9,138	9,439	9,776	10,155	
iii.	Septage Clearance Equipment	Rs in Mn	7.20			0.80		*8.00*
iv.	Construction of septage treatment facility	Rs in Mn	7.84					*6.45*
	Total Capital Investment	***Rs in Mn***	***15.04***			***0.80***		***15.84***
v.	Annual O&M of septage clearance equipment	Rs in Mn	4.92	4.92	4.92	5.41	5.41	
vi.	Annual O&M of septage treatment facility	Rs in Mn	0.47	0.47	0.47	0.47	0.47	
	Annual O&M Expenditure	*Rs in Mn*	*5.39*	*5.39*	*5.39*	*5.88*	*5.88*	
	Indicative Septic tank clearance charge	*Rs/ tank*	***608***	***590***	***571***	***602***	***579***	

TABLE (4.6): COMPONENT-WISE INDICATIVE INVESTMENT REQUIREMENTS, O&M COSTS AND USER CHARGES

Note:

1. In case of Septage Treatment Facility and Wastewater Treatment Facility, O&M expenditure starts only after construction is completed

Source: Hoshangabad CSP Analysis, 2010

The infrastructure requirement projections are based on the population growth patterns and infrastructure costings from project data for infrastructure projects implemented in various Indian cities between 1998 and 2006 as given in Table 3.3. A toolkit is being developed that will help cities undertake similar simulations for their respective case. For more details on the toolkit please refer to www.urbanindia.nic.in.

The annual O&M cost of septage clearance equipment and treatment facility is expected to be about Rs 5.88 million in year 5 (fully functional and effectively operated system). This can be met from user charges levied at the rate of Rs 600 per tank.

Key benefits and challenges of the 'fully on-site sanitation' approach for Hoshangabad are presented in Table (A.4).

Table (A.4): Fully On-site Sanitation: Benefits and Challenges

Benefits	Challenges
• Low public investment (less demanding on public resources) • Can be easily set-up • Will not lead to wastage of the private investment already made in septic tank construction • Citywide sanitation can be achieved faster	• Risk of groundwater pollution will have to be evaluated as the HNPP draws groundwater for municipal water supply • Finding place for constructing soak pits in all households will be a challenge • HNPP will need to institute septage management system[5] • New rules and regulations[6] relating to septage management will have to be introduced

[5] This shall broadly include maintaining a record of all households/ institutions using septic tanks, dates of last septage clearance, issuance of notice for timely clearance and periodic inspections. The system shall also include technical clearance of septic tank designs and inspection during construction for new properties coming up in the town.

Source: Hoshangabad CSP Analysis, 2010

As presented in the illustration above, ULBs will need to arrive at norms and standards as provided in CPHEEO Guidelines, and wherever these do not exist, formulate their own standards and norms with support from the State Government.

The second important step is to devise the unit costs for each of the components following the relevant Schedule of Rules, and/or Market rates existing in the city as may be appropriate,

The third steps is to compute the capital and O&M costs as presented in the illustration above. This will need to be followed by examination of the sources capital and revenues and subsidies (for O&M costs). A cost benefit analysis is also recommended for cities where capital and O&M costs turn out to be substantial,

11. Personnel, training and capacity building:

A separate Sanitation Cell has been recommended for CSP planning and implementation. It is recommended that this Cell should have the full responsibility for septage management in the city. Apart from deploying full-time personnel, there will be need for their capacity building and training. A list of Training Organizations is provided in the Annexes, where ULB personnel can be sent for training programs.

12. Communications and Community Participation

The NUSP overview of the sanitation situation in urban India points to the low priority accorded to sanitation and the lack of awareness about its linkages with public health. The fact that significant proportion of urban households are currently not connected to a sewerage network, highlights the importance of on-site sanitation arrangements at the household level and unregulated nature of construction and septage disposal practices enjoins the need for making them aware of safe management practices, citizen's civic responsibilities and the duties of civic bodies (and facilities offered by them). In such a scenario of decentralized use and management needs, there is the felt need for differentiated communication (in terms of messages and channels) to target different stakeholders like the municipal agencies, other frontline government agencies and most importantly, the people of the city. These will need to focus not just on awareness building, but also on inculcating behavior change amongst the various constituents of civic society.

The socio-cultural biases against sanitation and sanitary work need to be targeted, and dignity and humane approach promoted in the elevation of priority to sanitation in public affairs. The visibly negligent attention towards occupational hazards faced by sanitation workers in

[6] Current septage clearance practice is to respond to a call from property owner. This will have to change to proactive septage clearance system to be put in place and practiced. Also, HNPP will need to decide on septage clearance service charges.

the cities, needs immediate attention, due to its attendant public and personal health implications and also the negation of right to dignity enshrined in our constitution.

In preparing and implementing City Sanitation Plans (CSP), the cities will need to bear in mind the need and advantages (in a data-sparse environment and with numerous variations of sanitation arrangements) of a participatory approach, to ensure speedy and informed planning and implementation. Further, the public-good nature of urban sanitation necessitating collective action needs to be highlighted in the minds of all stakeholders. The public health implications of insanitary disposal and faulty sanitation arrangements make it all the more crucial that a participative and transparent approach with multiple streams of communication to identified stakeholders, form one of the pillars of the CSP strategy.

Awareness needs to be created amongst the authorities, households, communities and institutions which are part of the city fabric, about sanitation and its linkages with public and environmental health. CSP implementation strategies and the communication component of this should also seek to promote mechanisms to bring about and sustain behavioral changes aimed at adoption of healthy sanitation practices.

Communication would need to make use of popular and cost-effective channels (hand bills, notices, announcements in radio/TV, part of water bill, etc.) and messaging would need to be oriented to different stakeholders – households, institutions, government agencies, etc.

13. Summary of Steps in Planning and Implementation

a) Collect data on the households and other properties with on-site arrangements in the city

b) List out the municipal, private and other septic tank/pit cleaning services active in the city

c) Identify catchment-wise land for septage treatment facility: use existing STP where available; identify lands adjoining landfill sites or acquire land if not available

Table: Guidelines for selecting treatment and disposal options and financing norms for septage

Town Category	Conditions	Recommended Technologies	Capital Cost	O&M Cost	Facility Ownership	Financing Norms
Unsewered Class-III, IV and V towns and rural communities	Remote lands are available with suitable site and soil condition	Land application of septage	Low	Low	Municipal or Private	Fees to users
	Land available but close to neighbour	Land application after stabilization	Low to medium	Low to medium	Municipal or Private	Fees to users

Town Category	Conditions	Recommended Technologies	Capital Cost	O&M Cost	Facility Ownership	Financing Norms
	Inadequate land area available with suitable site and soil condition, WWTP available within 30 km with adequate capacity	Disposal at WWTP	Low to medium	Low to medium	Municipality	Fees to users
Partially sewered Medium size (class-II towns)	Land area available with suitable site and soil condition but close to settlements	Land application after stabilization	Low to medium	Low to medium	Municipal or private	Fees to users
	Inadequate land area, but available WWTP capacity	Disposal at WWTP	Medium	Medium	Municipal or private	Fees to users
	lnadequate land area; no available WWTP capacity	Disposal at independent treatment facility or CSTF**	High	High	Municipal or private	Fees to users
Class-I and Metrocities	Available WWTP capacity	Disposal & NhTP	Medium	Medium	Municipal or private	Fees to users
	No available WWTP capacity	Independent septage treatment facility or CSTF	High	High	Municipal or private	Fees to users
* Common Septage Treatment Facility						
Source: CSE, 2010						

d) Formulate draft regulations for septage management

e) Choose technology for septage treatment: preparer design of Septage Treatment Facility (STF) disposal along with costs

f) Conduct Techno-economic feasibility of the STF

g) Implement construction of septage management facility

h) Purchase vehicles and vacutugs etc. Safety Gear, SOP

i) Launch awareness campaign

j) Training and capacity building

k) Provision of cleaning services incrementally in areas completing surveys of tanks and pits

Selected References

Annexes

i. Definitions: Septage, sullage, sewage, biosolids, pathogens, etc.

ii. Effluent Standards for septage (CPCB)

iii. On-site Sanitation: Design Considerations (refer to ISO and CPHEEO and Tech Options)

iv. On-site Sanitation: Maintenance Management (refer to ISO and CPHEEO and Tech Options)

v. Septage removal and conveyance equipment: Standards and Specifications and Costs (CPHEEO – give a draft)

vi. Technical Options for treatment and safe disposal in cities without STPs (CPHEEO, WHO, relevant International experiences)

The Manual on Sewerage and Sewage Treatment of the Central Public Health and Environmental Engineering Organization (CPHEEO), MoUD, sets out technical norms for best practice in on-site sanitation and wastewater management. The manual covers planning, design, and construction aspects for a wide range of technical options; it also includes operation and maintenance aspects and safeguards to prevent water pollution under different soil and groundwater conditions. The norms set out in the manual are not mandatory but provide guidance for engineers. The manual also makes reference to relevant **Indian Standards and Codes of Practice notified by the Bureau of Indian Standards**. The most relevant include the following:

- IS 1172:1993 – Basic requirements for water supply, drainage, and sanitation.
- IS 12314:1987 – Code of Practice for sanitation with leach pits for rural communities.
- IS 2470 (Part 1):1985 – Code of Practice for installation of septic tank: design criteria and construction.
- IS 2470 (Part 2):1985 – Code of Practice for installation of septic tank: secondary treatment and disposal of septic tank effluent.
- IS 9872:1981 – Precast concrete septic tanks.
- IS 5611:1987 – Code of Practice for waste stabilization ponds (facultative type).
- IS 10261:1982 – Requirements for settling tanks (clarifier equipment) for wastewater treatment.
- IS 13496:1992 – General requirements for suction machines for cleaning sewers, manholes and so on.

In addition, the MoUD prepared a document entitled 'Technical Guidelines on Twin-Pit Pour-Flush Latrines' in 1992, which broadly follows the lines of IS 12314:1987 on leach pit construction in rural areas. All Indian Standards' codes represent a standard of good practice and therefore take the form of recommendations. They are not mandatory unless made so under contract conditions and some are routinely ignored, for example the recommendation for the construction of soakaways, dispersion trenches, and biological filters to deal with the outflow from septic tanks; and for the regular desludging of septic tanks using specified equipment.

The 1983 National Building Code of India (NBC) governs the design, installation and maintenance of toilets, septic tanks, and sewers. Part IX, Chapter VI, Section A on "Drainage and Sewerage" specifies the sizing and design of septic tanks, sewers, toilets, and other sanitation devices. The NBC also suggests that use of septic tanks without follow-up treatment is not permitted, as the effluent from the septic tank is hazardous from the point of view of health and pollution.